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ABSTRACT

Telecommunications and information technologies can advance school reform to ensure the achievement of high standards if the curriculum guides the investment in technology. Technology must be planned for, and it must be implemented slowly, as an essential part of the curriculum and not as an add-on result of available funds. Systemic reform linked to efforts to build the National Information Infrastructure can have enormous impact on teaching and learning, making access to information easier and active participation by students easier and more appealing. Use of technology to help reduce educational inequity can be achieved if technology is accessible and affordable for all. In addition, students and teachers must have the support they need to be able to reap the benefits of technology. Changes throughout the school organization, particularly in the area of professional development, are necessary to integrate technology into instruction. Funding the necessary infrastructure is a complicated problem, but public-private ventures and regional consortia present two possible avenues of financial support. Ten appendixes provide supplemental information, including legislative background. (Contains 64 references.) (SLD)

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Byting Back: Policies to Support the Use of Technology in Education

by Rafael Ramirez and Rosemary Bell
North Central Regional Educational Laboratory

U.S. DEPARTMENT OF EDUCATION
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Executive Summary

Rallying cries for high standards for all students can be heard in education circles across the country. Telecommunications and information technologies will advance school reform to ensure the achievement of high standards if the curriculum guides investment in technology. Technology must be planned for within the context of curriculum goals, student achievement, and affordability, and it must be implemented slowly. Technology also must be viewed as an essential part of the curriculum and not something that is just added on as funds become available.

Systemic reform efforts need to be linked with efforts to build the National Information Infrastructure (NII). Policymakers at the federal, state, and local level need to consider the following issues when designing a plan to connect educators and students to the NII:

Technology can have an enormous impact on teaching and learning.

- Technology can accomplish a range of goals from instructional to managerial to assessment.
- Technology reduces the "teacher as lecturer" approach and invites active participation by students. Research indicates that students internalize concepts when they are actively involved with what they are learning—manipulating data, asking questions, and consulting with peers and experts.
- Accessing information will be much easier for students and teachers.
- Classrooms will be more closely linked with real world activities and situations. Students will have opportunities to solve relevant tasks or problems in each discipline by accessing primary data sets, such as photographs taken by the Hubbell telescope or historical texts through the Library of Congress.
- Teachers will be able to report and chart progress on a more individualized basis while learning experiences become more collaborative.

Use of technology as a tool to help reduce inequities can be achieved only if policies ensure that technology is accessible and affordable to all classrooms. In addition, all students and teachers must have the support needed to reap the benefits of the full range of learning opportunities that technology supports.

- If governmental policies do not specifically guarantee universal access, then technology has the potential to exacerbate existing inequalities.
- Technology can remove the barriers of time and distance, permitting students from rural communities or from communities without adequate resources to access experts and information sources to the same extent available in more affluent areas.
- As a first step, districts should encourage the development of legislation and policies at the state level that would provide for basic funding of easy and affordable access to the Internet for schools.
- When planning any electronic networking system, states must consider "hidden costs" of maintaining and updating the system.

Integrating technology into the fabric of instruction requires changes throughout the school organization.

- Resources such as personnel, hardware, and software must be available and accessible. In addition to professional development, teachers need easy access to technical support, especially in the beginning. Technical support means having people who are experts in the technology available to fix quickly any mechanical and operational difficulties experienced by teachers or students.
- Changes in the structure of schooling, such as the length of the school year, can go a long way toward creating opportunities for greater integration of technology.
- Teachers are less likely to use technology if they have to go to a remote location during a slotted time period to use it.
- Different types of technology may be used to meet different needs at various sites within the classroom, the school, or the district—e.g., use older computers for simpler tasks such as keyboarding, spelling, and reinforcement.
- "Low-tech" technologies, such as e-mail, bulletin boards, and gophers, can lay the groundwork for full and widespread use of more advanced technologies. Once teachers see the utility of the more user-friendly "low-tech" technologies, they will be much more anxious to use and see the benefits of the more advanced technologies.
- Telecommunications and information technologies could make it possible to address the nonacademic needs of students more efficiently and effectively. This use of technology would entail connecting other social service agencies and education institutions with technology, so that they can share information to avoid duplication of services and to serve a child's needs more comprehensively.

Professional development, especially when it is connected to the high standards called for by the systemic reform movement, is crucial to integrating technology successfully into classrooms.

- Investment in professional development should be at least equal to investment in the technology itself.
- Starting slowly and planning for training in the use of the technology, in learning theory, and in new content standards will allow teachers to see the most useful applications for different technologies and how technology can help them do their jobs better.
- Change works best when teachers are involved in making decisions and share new ideas with other teachers.
- Ensuring teacher access to and comfort with technology for their own uses is a necessary precursor to expecting extensive use with students.
- Principals can act as leaders of change and modelers of technology use.
- Investing in lead cadres of teachers who share expertise with colleagues maximizes the leverage of professional development.

- School faculties should be given the flexibility to select the kinds of training and other development opportunities appropriate to their needs and preferences.

- Preservice teacher education programs should prepare teachers to understand what technology can do and how to use it.

- Videodisc technology offers a way for novice teachers working with mentor teachers to examine different factors that influence teaching and learning.

Public/private ventures and regional consortia present two possible avenues for funding the necessary infrastructure.

- Public/private ventures stem from a recognition that the business community has a stake in the quality of education received by future employees. They capitalize on the financial support of private industry to work for the improvement of education.

- Public/private ventures benefit both business and education entities, because technology can be used by schools during the day and by business employees and extension program students in the evening.

- Regional consortia create economies of scale for the education community by pooling resources of schols, districts, or states. In this way, they have increased control in articulating demands and shaping the education marketplace. They not only ensure reduced prices for any investment in technology but also ensure fewer and less costly problems in interfacing and expanding as the needs and/or the resources allow.

Byting Back: Policies to Support the Use of Technology in Education

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Introduction

Numerous attempts have been made to describe systemic reform in education (Cohen, 1989; Smith & O'Day, 1990; Tye, 1992), but little discussion has been devoted to linking telecommunications and information technology policies with school reform policies. This paper will present the rationale for linking systemic reform efforts with efforts to build the National Information Infrastructure (NII). The NII *will* be built; it is the future, and education needs to be a part of that future.

This paper provides a framework for thinking about the broad range of issues that will need to be considered in applying technology to support educational goals. Because the number of technologies now available to schools has grown so rapidly, schools have few, if any, guidelines to follow in planning for this investment. One guideline that we assert again and again is that the needs of the curriculum must guide investment in technology.

The overall policy issues in this paper address two questions: (1) how well are the developing telecommunications and information technologies being applied to support school restructuring efforts? and (2) how will the deployment of these technologies in the classroom be funded? The premise throughout this paper is that, unless the goals of the curriculum drive investment in technologies, the inequities that exist in our school systems will only increase.

This paper provides a framework for thinking about the broad range of issues that will need to be considered in applying technology to support educational goals.

We examine the role of each level of government in order to discuss the systemic nature of these issues, especially as the various governmental bodies seek to coordinate their efforts in investing in technology for the schools as a way to enhance instruction. Failure to coordinate these efforts in linking schools electronically will further widen the gap between the technology "haves" and the "have nots" in our schools.

Thus, our paper is based on the following premises:

- Implementation of school reform and the achievement of high standards will occur only if telecommunications and information technologies are fully integrated into the curriculum.
- Equity in the form of universal access to telecommunications and information technologies will have to be ensured to avoid exacerbating existing inequities.
- Specific curriculum goals based on what research tells us about learning should drive selection of technology, while long-term planning and funding are necessary for achieving these goals.
- Support in integrating technology into the curriculum must be provided through sustained staff development.
- The technology systems should, at the very least, be flexible enough to
  - Accommodate different student learning styles
  - Encourage a participatory learning environment
  - Provide alternative strategies by which teachers can adapt their teaching styles
  - Develop a community of learners that connects resources and people
- Public/private ventures and regional consortia must be considered for funding the infrastructure development that will be necessary.
  - Because of economies of scale, schools will work with community and other institutional networks in order to fully implement appropriate use of the opportunities provided through and with telecommunications.

This paper is divided into three major sections. In the first section, we make a case for integrating technology into the education system for reasons of school reform, equity, and research on educational applications of technology. The next section discusses the infrastructure that must be in place in order to integrate technology, with a focus on planning at the different levels of government; linking research on staff development to school reform; and identifying the most appropriate ways to deploy technology in the schools. The final section explores alternative ways to pay for integrating the technology into education.

The use of technology as a tool to help reduce inequities can be achieved only if policies ensure that technology is accessible and affordable to all classrooms.

Section one explores equity, standards, and interactive learning and why they are important issues for education. The policy statements are as follows:

- The use of technology as a tool can reduce existing inequities. Policies must ensure that technology is accessible and affordable to all classrooms and that all students and teachers have the support needed to reap the benefits of the full range of learning opportunities that telecommunications systems and information technologies support.
- High standards apply to all students and applying information technologies to education will support the implementation of high standards for all students more equitably than any other alternative to restructure schools.
- Applying technology appropriately to professional development will best ensure that more teachers take on the role of facilitator in the classroom and generate environments in which students become actively involved in their own learning.

The second section focuses on how different levels of government can or should contribute to school reform efforts. The federal government, for instance, will concentrate mainly on policies relating to universal access and affordability in developing the NII, as well as supporting the states in their development of challenging state content and performance standards. The state will be concerned mainly with connecting to the NII, developing state content and performance standards supported by appropriate technology applications, and providing technical support and professional development opportunities to schools. The school, as the point of implementation, will be responsible for helping students master the content standards, with an emphasis on using technology as a tool to do so. The following are policy statements on this issue:

- Federal legislation, such as S. 1040 and H.R. 6, must retain their numerous provisions to support states and districts in planning for and implementing technology in the schools. The development of the NII that occurs at the federal level will have to ensure affordable and universal access to schools to support them in these activities.
- The role of state legislation must be focused on providing resources to the districts and schools making it possible for schools to connect telecommunications and information technologies. Assistance at this level will address issues such as planning for connectivity, maintenance, technical standards, and financing.
- District policies must concentrate on professional development in the areas of content and professional standards, project-based learning, and applying technology to the daily curricular activities.
- Staff development must be a key component in the application of technology to support educational reform. Teachers must have support in identifying the most effective research-based curriculum models as well as technical support in choosing technologies and integrating them appropriately into the curriculum.

We examine the role of each level of government in order to discuss the systemic nature of the issues.

Finally, the last section explores the various funding alternatives, such as public/private ventures and regional consortia, that schools could use to increase their buying power and make possible the establishment of more integrated technology systems. We define these alternatives as follows:

- Large scale public/private ventures put the financial support of private industry to work for the improvement of education in a more systemic manner.
- Regional consortia can create economies of scale for the education community. Pooling resources allows schools, districts, and states to create environments in which they have increased control in articulating demands and shaping the education marketplace.

These ideas illustrate the array of policy issues that must be considered by various policymakers responsible for education at the federal, state, and local levels. We have an education system and each level of decisionmaking should understand the concerns at each of the other levels, especially as they apply to policies connecting education to the NII.

Summary of Policy Recommendations

These ideas suggest a number of recommendations. Greater detail is provided at the end of the paper, but a summary of the main recommendations that we make in relation to each level of government follows:

Federal Level

- Enact legislation such as S. 1040 (Technology for Education Act of 1994) and H.R. 6 (Elementary and Secondary Education Act). These bills, when enacted, should include a clear focus on ways to provide resources for professional development and technology implementation, and should have provisions for planning grants and grants for hardware acquisition.

- Connect investment in educational technology to state plans for achieving challenging state content standards, based on the standards being developed in the content areas by national professional organizations.

- Enact legislation, under the auspices of the Department of Commerce (DoC) and the Department of Education (DoEd), to connect all students to the Internet.

State Level

- Enact legislation that supports the activities identified in federal legislation such as S. 1040 and H.R. 6 and provides resources in the areas of technical support, professional development, planning, and leadership, among others.

- Develop and implement state regulations that make it possible for schools to have universal and affordable access to telecommunications and information technologies.

Local Level

- Foster a community of learners by using the professional development resources available from the state to support teachers and students in their use of inquiry-based learning strategies.

- Tap content area expertise held by teachers and administrators in the district.

- Develop strategies for using telecommunications and information technologies to access national and state databases with the curriculum.

Section One

In this section, we present the case that guaranteeing access for all classrooms to affordable telecommunications and information technologies to help achieve specific curricular goals provides the best set of alternatives to address the almost intractable problem of inequities within our school system. School reform at both the federal and state levels focuses on developing and implementing more challenging standards for all students. Access to technology at an affordable rate for all classrooms will allow students to interact with all of the resources, materials, and data sets on these systems in meaningful and relevant learning environments. These telecommunications and information technology systems, when used at the classroom level to help achieve the challenging content standards that are under development, will provide very powerful alternatives for creating more effective learning environments for all students.

Education policymakers must consider how issues such as interconnectivity, electronic networks, telecommunications, and information technologies must become tools for providing a quality education. The following questions must be answered:

- Why should our schools become connected electronically?
- How should our schools be connected?
- Should the new telecommunications and electronic capabilities be used to support the old paradigm, or should it be used to help implement a new paradigm?
- How can technology best be adapted to our schools to support change in the K-12 curriculum?
- How will these information technologies affect the way teachers teach and students learn?
- Who will pay for this electronic interconnectivity?

Access to technology at an affordable rate for all classrooms will allow students to interact with ... resources, materials, and data sets ... in meaningful and relevant learning environments.

Setting the Stage

Communications and Computing

> *Education is the only segment of America that has not been revolutionized by technology...*
>
> *Schools are one of the few social institutions in the knowledge and information business that have relatively little ongoing access to knowledge or information sources and resources.*
>
> Senator Jeff Bingaman (D-N.M.)
> Introduction of S. 1040
> Speech given in the U.S. Senate, 1992

As communications and computing merged their technologies, businesses and industries that rely on information invested in telecommunications systems that made moving and managing information easier. With the ability to integrate voice, data, video, and still images, interactive, multimedia networking is becoming a reality. Multimedia networking will carry services that include everything from home shopping to video-on-demand to electronic mail and messaging to ultra high-speed information transfer. Business and industry have already integrated electronic information systems to access databases and information resources from all over the world and, in effect, have helped create the global marketplace. At the same time that the telecommunications and information services industry was undergoing rapid change, the education system was just beginning to change the way it does business.

As information becomes more and more available through the use of technologies, it will become more and more important to have skills in analyzing, synthesizing, and communicating this information.

During the 1980s, reform initiatives started as top-down efforts to lengthen the school day, increase the requirements necessary for graduation, and use assessments to determine competency in basic skills. These attempts were followed by efforts to address more systemic issues, such as decentralization, professionalization, and equity. All of these activities have contributed to keeping education reform a topic of national debate for the past decade.

However, while individual schools and districts made dramatic changes in school governance and structure as well as in education practice and programs, the system as a whole showed little improvement. In fact, researchers differ in their measurement of the effects of these efforts. Mullis and Jenkins (1990) find little evidence of meaningful gains in learning. Bracey (1992) and Jaeger (1992), on the other hand, argue that the system is making remarkable progress.

While the debate over how well the system is working continues to rage, few disagree on the necessity of restructuring schools to meet the demands of the current era of telecommunications and information technologies. The school system as we know it, from the length of the school day to the teaching strategies used to foster learning, may have been appropriate in the past. However, it does little nowadays to ensure that students leaving high school or college will have the skills necessary to earn a living in the modern workplace. One futurist notes that

> *[w]hite collar tasks are being automated faster than blue collar jobs. Eighty percent of what [anyone does] is better done by someone else or by a machine. Management need more retraining than workers. (Zach, 1993)*

The implication is that the education our students receive beyond high school is inadequate to meet the demands that they will face on the job. If this interpretation is accurate, we must realize that the disparity between what students learn in school and which abilities they will be called upon to use in the workplace will only continue to grow unless we make a concerted effort to change the way our schools do business.

Federal, state, and local agencies responsible for school programs have all begun to demonstrate a willingness to apply technology to the curriculum as a way to implement change in education practice. They foresee that such an approach will make it possible to prepare students better for the rapidly changing society in which we live, a society that uses technology to gather, analyze, and create information, as well as to communicate.

The National Information Infrastructure (NII) that is being created could not have been envisioned ten years ago. We are coming to the realization that schools and educators as well as parents and students should have a role in its development. Only in this way will it be possible to ensure that students are provided with the kinds of learning environments and skills that will enhance their chances of obtaining jobs and to provide them with the opportunities to continue to learn and receive training. As information becomes more and more available through the use of technologies, it will become more and more important to have skills in analyzing, synthesizing, and communicating this information. It is a matter of course that helping students develop these skills must guide education's investment in technology.

Why Should Our Schools Become Connected Electronically?

Goals 2000: Educate America Act (P.L. 103-227)

On March 31, 1994, Goals 2000: Educate America Act was signed by President Clinton and became Public Law 103-227 (108 Stat. 125). The first three titles of this law, in particular, will act as the guiding force for education initiatives from the federal level. They address the goals that must be sought and the activities that must take place at the state and local levels to meet the promise of ensuring that all students achieve high standards. Title I, National Education Goals, describes the goals themselves and the objectives attached to each goal. Title II, National Education Reform Leadership, Standards, and Assessments, includes three parts that are key to the implementation of the national goals: Part A, National Education Goals Panel; Part B, National Education Standards and Improvement Council; and Part C, Leadership in Educational Technology. Title III, State and Local Education Systemic Improvement, describes how the improvement process will unfold.

Legislating national education goals defines the direction in which the Clinton Administration believes education in this country ought to be heading. The federal government has never before offered direction and guidance of this nature. The Administration intends for this legislation to provide the foundation for all future education legislation introduced by the Administration. Goals 2000 will legislate the National Education Goals and develop a process for establishing national education content standards, student performance standards, and opportunity-to-learn standards. The legislation assumes that the development of higher standards for all students will drive education reform and restructuring in a systemic way and lead to higher levels of achievement for all students.

While there is no agreed upon definition for systemic reform, all of those who discuss systemic reform in education do agree on one concept: Education must reflect the belief that learning is lifelong and does not stop with graduation from high school or college. Implicit in this notion of lifelong learning is that we must provide opportunities for learning from preschool through late adulthood. The National Education Goals reflect this concept of lifelong learning by including goals that cover preschool, elementary, secondary, postsecondary, and adult education, as well as professional development and parental involvement.

Legislating national education goals defines the direction in which the Clinton Administration believes education in this country ought to be heading. The federal government has never before offered direction and guidance of this nature.

Statistics show that today a 17-year-old will change his or her job/career seven times within a lifetime. If this prediction is true, we must question whether we are preparing students to accept these changes as new opportunities and whether our education system is set up to allow individuals to return to school at any time in their life to obtain new skills commensurate with their career changes.

The National Education Goals emphasize this notion of lifelong learning and challenge our education system, as well as business and industry, to define standards that will provide children and adults with opportunities for lifelong learning. We must define what we mean by having children ready to enter school and know how we will support this goal through preschool opportunities. We must make clear what we mean when we say that all adults will be literate by the year 2000 and how we will help make this goal a reality for our 18+ population.

The National Education Goals cover the entire spectrum of education from just after birth through old age. They also stress ways in which the school can become the focal point for learning activities of all kinds in the community, bringing life to the meaning of the term lifelong learning, involving parents, and supporting professional development for all teachers consistent with the different expectations for teachers.[1] In other words, opportunities to learn will be available for anyone at any time and at any point in one's career.

An important question to consider is how we can restructure the education system to meet these goals. To help achieve these goals, we must realize that other social service agencies and education institutions also need to be connected with technology.

The National Education Goals[2]

Goal 1 **School Readiness**

By the year 2000, all children in America will start school ready to learn.

Goal 2 **School Completion**

By the year 2000, the high school graduation rate will increase to at least 90 percent.

Goal 3 **Student Achievement and Citizenship**

By the year 2000, all students will leave grades four, eight, and twelve having demonstrated competency over challenging subject matter, including English, mathematics, science, foreign languages, civics and government, economics, art, history, and geography, and every school in America will ensure that all students learn to use their minds well, so that they will be prepared for responsible citizenship, further learning, and productive employment in the nation's modern economy.

Goal 4 **Teacher Education And Professional Development**

By the year 2000, the nation's teachers will have access to programs for the continued improvement of their professional skills and the opportunity to acquire the knowledge and skills needed to instruct and prepare all American students for the next century.

Goal 5 **Mathematics and Science**

By the year 2000, U.S. students will be first in the world in mathematics and science achievement.

Goal 6 **Adult Literacy and Lifelong Learning**

By the year 2000, every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship.

Goal 7 **Safe, Disciplined, and Alcohol and Drug-Free Schools**

By the year 2000, every school in the United States will be free of drugs, violence, and the unauthorized presence of firearms and alcohol and will offer a disciplined environment conducive to learning.

Goal 8 **Parental Participation**

By the year 2000, every school will promote partnerships that will increase parental involvement and participation in promoting the social, emotional, and academic growth of children.

The addition of two new goals to the original six goals, one addressing the professional development of teachers and the other addressing the involvement of parents in the education of their children, highlight the importance of these roles to a child's success in school. In addition to providing teachers and parents with the support that they require to meet the needs of students, the goals emphasize that both teachers and parents should have access to training. The belief is that such access will enable teachers and parents to serve the children better.

Teachers will be expected to become increasingly well-versed in the use of teaching strategies and technologies in order to support student learning.

The point being made in making these activities a part of the National Education Goals is that everything students, teachers, and parents will have to do to reach these goals is closely connected. The extent to which the goals represent a continuum of learning provides the definition of what we mean by lifelong learning—that is, the opportunity to continue learning at any point in one's life in the appropriate environments. It is expected that parents will become involved in decision-making at the school and will support these decisions in the way in which they interact with their children at home. Teachers, on the other hand, will be expected to become increasingly well-versed in the use of teaching strategies and technologies in order to support student learning. When parents and teachers take on these kinds of roles, children will have a better chance to meet the goals that apply directly to them.

Teachers and teaching skills are a major component of the education initiatives at the federal level, which is demonstrated by the addition of professional development as Goal 4, as well as the emphasis on professional development in related pieces of legislation such as H.R. 6, the Elementary and Secondary Education Act (ESEA). One component of H.R. 6, Title II—Improving Teaching and Learning, Part A—Dwight D. Eisenhower Professional Development Program, specifically addresses the importance of providing support to teachers in the quest to help students meet the National Education Goals and reach the challenging new state standards that are under development. The ESEA, for instance, requires that state and local plans describe professional development activities in the following areas:

State level (Sec. 2124 State Applications)

> *(2) Each such plan shall also—*
>
> *(A) be developed in conjunction with the State agency for higher education, institutions of higher education, schools of education, and with the extensive participation of teachers and administrators and members of the public who are interested in improving education in the state and show the role of each in implementation;*
>
> *(B) be designed to give teachers and administrators in the state the knowledge and skills to provide all students the opportunity to meet challenging state performance standards;*
>
> *(C) include an assessment of state and local needs for professional development and for the development of curricula that are aligned with state or local content and performance standards; . . .*
>
> *(E) include a description of how the plan has maintained funding for professional development activities in mathematics and science education; . . .*

Local level (Sec. 2126 Local Plan and Application for Improving Teaching and Learning)

> *(3) Based on the needs assessment required under subsection (b), the local educational agency's plan shall include the following—*

> *(A) a description of the local educational agency's strategy to improve teaching and learning in every school;*
>
> *(B) a description of how the plan contributes to the local educational agency's overall efforts for school reform and educational improvement; . . .*
>
> *(D) a description of how the plan has maintained funding for professional development activities in mathematics and science education . . . [H.R. 6.]*

Sec. 2206 Elementary and Secondary Education Programs gives specific examples of the types of technologies that would be favorably looked upon as part of a technology use plan from a local educational agency.

The bill goes on to describe, in Sec. 2125 State-Level Activities, what some of the activities associated with these areas might look like. The application of educational technology to these tasks is addressed specifically:

> *Each state may use funds reserved under section 2123(a)(2) to carry out activities referred to in section 2124(b), such as— . . .*
>
> *(6) enhancing the effective use of educational technology as an instructional tool for increasing student understanding of the core academic subject areas including—*
>
> > *(A) efforts to train teachers in the innovative uses and application of instructional technology;*
> >
> > *(B) utilizing and strengthening existing telecommunications infrastructure dedicated to educational purposes; and*
> >
> > *(C) efforts to train teachers in methods for achieving gender equity both in access to and teaching practices used in the application of educational technology; . . . [H.R. 6]*

In addition, Sec. 2202 Findings, of Part B—Technology Education Assistance, Subpart 1—Assistance to State and Local Educational Agencies, identifies technology twice as an essential component preparing teachers to use new instructional strategies:

> *(7) telecommunications can be a conduit for ongoing teacher training and improved professional development by providing to teachers constant access to updated research in teaching and learning;*
>
> *(8) research consistently shows that the planned use of technology combined with teachers who are adequately trained in its use can increase opportunities for more students to develop higher order thinking and technical skills than is possible with traditional instruction; . . . [H.R. 6]*

Sec. 2203 Statement of Purpose buttresses these findings and seeks to provide

> *(4) an extensive variety of opportunities for teacher, inservice training, and administrative training and technical assistance with respect to effective uses of technologies in education; . . .*
>
> *(8) authorize grants to states that— . . .*
>
> > *(B) strengthen the skills of teachers in effectively utilizing technology for student learning;*
> >
> > *(C) promote the planned application of technology in education by those who will use the technology; . . . [H.R. 6]*

Sec. 2206 Elementary and Secondary Education Programs gives specific examples of the types of technologies that would be favorably looked upon by the state as part of a technology use plan from a local educational agency. The state will be looking for

> *(G) a description of how the financial assistance will be used as appropriate for the expansion and improvement of professional development of teachers and other appropriate personnel regarding the use of technology, including the educational use of computers, videos, and telecommunications to enhance learning such training and instruction may be carried out through agreements with public agencies, private industry, institutions of higher education, regional educational laboratories and national research centers, nonprofit organizations (including museums) libraries, educational television stations; . . . [H.R. 6]*

H.R. 6 is not the only piece of legislation that calls for extensive professional development support, however. In fact, the ideas discussed above, although now incorporated into H.R. 6, were originally developed as part of H.R. 2728, the House initiative for educational technology. Goals 2000 also encourages state plans to include strategies for the provision of professional development in the area of technology as a way of helping students meet higher standards.

What becomes apparent is that professional development, including efforts targeted at the integration of technology, has been assimilated throughout the federal agenda for education. These efforts seek to provide support to administrators, parents, teachers, and students in making higher standards a key part of the curriculum.

However, if the schools adopt higher standards and are given more flexibility and assistance, they will have to take responsibility for achieving the standards and accept agreed-upon consequences for not achieving them. Accountability will be directly related to outcomes or increased student achievement, although achievement will be measured by means other than the traditional standardized measures. Technology can be tied to this process through both instruction and assessment. In other words, not only can the teacher use technology as a way to individualize instruction to help students strengthen particular skills that are vital to the achievement of certain standards, but it would also be possible to measure achievement using technology-based assessment methods.

Professional development, including efforts targeted at the integration of technology, has been assimilated throughout the federal agenda for education.

National Content Standards

In order to create the kind of agreement on what will be expected in each of the curricular areas with this new emphasis on student-centered, inquiry-based-learning, the Department of Education, through the Office of Educational Research and Improvement (OERI), has funded eight national groups to develop content standards in each major curriculum area.[3]

Independently, the National Council for Teachers of Mathematics (NCTM) developed its own set of standards for grades K-12. With the endorsement of the National Governors Association, these standards have become a national model for the development of content standards in the other curricular areas. In addition, NCTM is developing standards for assessment linked to the content standards.

Bruno Manno (1994) suggests that the development and implementation of the NCTM standards is an example of systemic reform in mathematics:

> *After the NCTM standards were published in 1989, states began creating new curriculum frameworks and revising their guidelines for teaching mathematics. They guide and focus what happens in the classrooms by stating major issues, themes, and questions to be discussed and the essential knowledge, skills, and understandings to be learned and mastered.*
>
> *Textbook publishers began revising their texts and aligning them with the NCTM*

> *standards. Commercial test publishers realigned their tests with the NCTM standards and state frameworks. Educational technology producers shifted more toward problem solving modalities. Professional training programs retrained teachers to help them change what they do in order for the teachers to be able to teach to the new standards. Approximately 40 states are now using NCTM standards as a basis for staff development in mathematics. (p. 23)*

The Administration White Paper on Communications Act Reforms ... laid out five fundamental principles for legislative and administrative reform of telecommunications policy.

The NCTM standards imply more than just a set of curricular goals that students will be expected to master. Accompanying the curriculum and evaluation standards are professional standards for the teaching of mathematics. These standards focus on methods and strategies that will enable teachers to provide the most effective instruction in the curriculum—but this goal cannot be achieved without adequate staff development.

How Should Our Schools Be Connected?

National Information Infrastructure (NII)

At the federal level, the Clinton Administration has responded to the developing telecommunications and information infrastructure and the call for school reform with the creation of the NII and has released two documents addressing the intent and benefits of developing the NII. The first is the Administration White Paper on Communications Act Reforms, which was released in September 1993. It laid out five fundamental principles for legislative and administrative reform of telecommunications policy:

- Encouraging private investment in the NII
- Promoting and protecting competition
- Providing open access to the NII by consumers and service providers
- Preserving and advancing universal service to avoid creating a society of information "haves" and "have nots"
- Ensuring flexibility so that the newly adopted regulatory framework can keep pace with the rapid technological and market changes that pervade the telecommunications and information industries

The second document is the Agenda for Action: The National Information Infrastructure. The Executive Summary of this report outlines a vision of the impact of a completed NII on American life:[4]

> *All Americans have a stake in the construction of an advanced National Information Infrastructure (NII), a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips. Development of the NII can help unleash an information revolution that will change forever the way people live, work, and interact with each other:*
>
> - *People could live almost anywhere they wanted, without forgoing opportunities for useful and fulfilling employment, by "telecommuting" to their offices through an electronic highway;*
> - *The best schools, teachers, and courses would be available to all students, without regard to geography, distance, resources, or disability;*
> - *Services that improve America's health care system and respond to other important social needs could be available on-line, without waiting in line, when and where you needed them.*

> – *We need an information infrastructure that serves all citizens, not just a system that creates new jobs and new investments, although that is nice, too. The public sector is rarely served by new jobs and new investments.*

The emphasis at the federal level is on deploying the NII, with one of its purposes being to provide resources to education from a variety of agencies, including the Department of Education (DoEd), the National Aeronautics and Space Administration (NASA), the Department of Defense (DOD), the Department of Energy (DOE), and the National Science Foundation.

There seems to be agreement that schools should be connected and that being connected can contribute to the achievement of systemic education reform at the state and local levels. All students will be expected to achieve new challenging state standards and to meet the National Education Goals, but it is imperative that we provide the necessary support so that this transformation can occur.

Some Accepted Truths About the NII

While universal access may not be universally agreed upon, Kapor notes the consensus that seems to have been reached on some issues of control:

- **Private, not public**: Telephone companies and cable television operators—not the government—will be the principal carriers of traffic into the home. The government will concentrate its efforts on research and on settling legal issues.
- **A hybrid net:** Fiber-optic cables will be used in the major arteries and portions of the distribution system, while existing copper and coaxial cable will be used for the home.
- **Video driven**: Video will drive the market, both in the near term and more broadly. Movies on demand will soon be available to the home, opening up other markets such as voice telephone, video conferencing, and database access that telephone and cable companies are anxious to exploit. (Kapor, 1993, p. 54)

Given the above areas of agreement, educators must understand that there is no one right technology or system. Kapor makes predictions about transmission mediums and programs that could affect education because of their cost-effectiveness and their ability to meet current telecommunications demands. For example, he predicts the expansion of Integrated Services Digital Network (ISDN) as it grows in favor as a transmission medium for delivering and receiving information in a variety of forms. ISDN offers an increased band capacity that can connect to the NII with relatively low investment compared to fiber. Another important area of concern for education is that desktop video production will become increasingly popular because of its capacity to provide meaningful content not to a mass audience but to a select audience.

Educators must understand that there is no one right technology or system.

One state, Ohio, in considering changes to its telecommunications regulations, attached significant importance to universal access to services of this type:

> *Whatever the future holds, at this time, there are services which are essential to the public and for which there is no viable competition. These services should be provided at or below cost. (Public Utilities Commission of Ohio (PUCO), 1992, p. 18)*

Why Is Access to the Information Highway Important to Schools?

Less than 20 years ago, only 50,000 computers existed. Today, the computer industry will sell more than 50,000 computers in one day.

According to a recent report in *Business Week* (1994):

- One third of all homes in America have personal computers (PCs);
- Forty percent of those PCs have modems;
- Sixty percent of those PCs sold today come with CD drives;
- More than 4 million homes are using on-line services like CompuServe, Prodigy and America OnLine, and;
- Internet is growing at the rate of 15% per month and now reaches over 15 million people.

From the above statistics, it is clear that the public—or at least those who can afford it—wants communications technology. But what about the integration of technology into other aspects of the public sector, such as education? Do we see the same kind of statistics?

Technology is an area that has the potential for exacerbating inequities within our school system if we do not develop appropriate policies to prevent this negative impact.

Jacques Leslie makes note of the following statistics:

> *According to a Denver-based research firm called Quality Education Data (QED), out of the 83,790 public schools in the U.S., only 22 percent possess even one modem, and only 14 percent used educational networks in even one classroom in the last school year.*
>
> *. . . [W]hat impedes the growth [of technology in education] is a shortage of funds, teachers' and administrators' unfamiliarity with telecommunications, lack of time in the school schedule, and the lack of a national telecommunications infrastructure, including an almost universal absence of telephone lines to classrooms. (p. 38)*

In addition, Congressman Sawyer (D-Ohio), who serves on the Education and Labor Committee in the House of Representatives, states:

> *[M]ore than 50% of the computers in today's classrooms are 5 years old. Only 10% of teachers have a telephone line that can transmit data in their classrooms and only 4% have modems, which link computers over telephone lines. (Sawyer, 1994)*

While the use of telecommunications and information technologies is being embraced by business and industry and we are investing in this equipment for our personal use at home, education is just beginning, comparatively speaking, to think about investing in this area—an area that has the potential for exacerbating inequities within our school system if we do not develop appropriate policies to prevent this negative impact.

A key policy issue then becomes integrating services in order to address student needs in the most comprehensive way possible. If we believe that education will never meet the National Education Goals without restructuring systemically and that this goal cannot be achieved without making substantial use of telecommunications and information technologies, then it stands to reason that social service agencies whose clients include students would also need to integrate technology. In fact, H.R. 6, under Sec. 2214 Findings and Purposes, recognizes technology as an essential component in all settings connected with education:

> *technology can provide students, parents, teachers, and other education professionals with increased access to information, instruction, and educational services in schools and other settings, including homes, libraries, preschool and child-care facilities, and postsecondary institutions.*

In addition, it means that, as called for in the required State plans:

teachers, administrators, and other education personnel [will] have access to . . . the electronic transfer of, and access to, information.

Extending this application, telecommunications and information technologies shared with social service agencies would make it possible for any one service provider—whether it be the school, the local medical clinic, or a family counseling center—to have access to a full picture of a child's needs and how they are being met. In this way, duplication of services could be avoided and the needs of the individual child would be met more effectively.

Access to the NII and Equity

Open, affordable access to the NII may represent one way to guarantee all teachers and all students full access to educational resources and contacts, regardless of the location of a school or the financial condition of a community. A significant number of school districts in the United States are located in rural or urban areas where use of telecommunications systems is currently cost-prohibitive. If investment in telecommunications and information technologies in our schools can provide more equity, access to these systems and resources and their affordability for all schools must be addressed in any planning for the NII or complementary state networks. Unless access to electronic networks is guaranteed and affordable to all schools, further investment in the national information infrastructure at any level can only exacerbate inequities between the "haves" and the "have nots."

For example, according to Parker et al. (1991), rural communities are undergoing a decline that is not merely part of a cyclical process of readjustment. The global economy has introduced new forms of competition to local economies, not the least of which is the widespread use of telecommunications. Rural areas suffer in this regard because they lack the economies of scale and thus ease-of-access to the telecommunications services that metropolitan areas can take for granted. Left to their own devices, telephone companies might bypass rural areas, since these areas provide no profit margin.

Generally, rural districts and poor, urban districts have not been able to afford to modernize their buildings to take advantage of these new technologies. They also cannot afford equipment even if they can modernize their buildings. And even if they could afford to buy equipment and modernize their buildings, they would still have to figure out how to afford training for their teachers, ongoing maintenance and upkeep, and user fees for accessing the information resources. Policies, legislation, and support for implementing technology must take into account existing inequities and then devise financing plans that address these inequities by investing in technology in a way that does not exclude any student from access to these resources.

The NII is the future, and education needs to be a part of that future.

We are not advocating that all schools immediately put state-of-the-art equipment into their classrooms. To do so would beg the question of why a school, district, or state ought to invest in technology; as we have stated, the only reason to invest in technology is to enhance curricular goals. If certain technologies can help to achieve better student mastery of the curriculum, then appropriate technologies need to be implemented. It is at this point that we need to confront the issue of equal access for all students to what these technologies can provide and how they can best address school needs.

The NII is not built yet—it is in the process of being developed, and, as we have stated, multiple technologies that can be applied for multiple purposes in multiple settings are already available. Included in this list would be satellite, video, compressed video, cable, local area networks (LANs), and nonnetworked systems. In addition, most classrooms do not have access even to the Internet, although federal, state, and local initiatives are being developed to achieve this end. The NII is the future, and education needs to be a part of that future.

Universal Access Is Not a Universal Agreement

While we have argued above in favor of open, affordable access to the NII as essential for addressing inequities within the education system, access right now is generally unavailable and ineffective at the classroom level. The issue of equity in the use of technology will take a number of different forms over the coming years as the NII develops and as education begins to participate actively in it. Right now, many of the questions around equity have to do with who owns and controls the various networks that are available as well as the regulations that until now have guided the telecommunications industry.

Electronic networks, and the different methods of networking that are being created—whether over telephone or cable lines or a combination of the two—will bring up questions that we have never before had to address.

In essence, accessibility implies that anyone who wants to provide information ought to have access to anyone who wants to buy it. As Vice-President Gore (1994) stated on January 11 before the Television Academy:

> *How can government ensure that the information marketplace . . . will permit everyone to be able to compete with everyone else for the opportunity to provide any service to all willing customers?*

He also made clear that education must be a part of the NII:

> *I challenge you, the people in this room, to connect all of our classrooms, all of our libraries . . . by the year 2000.*

We know that one of the advantages of the developing NII will be a vastly expanded superhighway offering more and better options for using information technology. But access to these technologies is not equitably distributed and, particularly in our schools, there is a growing disparity between the technological "haves" and "have nots." If equitable access to information is not available on an as-needed basis or as a means to enhance instruction, will many of our students be at an educational disadvantage compared with students who have these technologies available to them in the classroom. Will our schools continue to perpetuate "savage inequalities," to use Jonathan Kozol's phrase, or can we use and support the integration of information technologies into all schools, ensuring that the most needy schools have the same access and support for integrating technology as the most technologically sophisticated schools? Policy decisions made about the NII will affect how teachers and students use online services, how these services will be accessed and paid for, and who will get these services first.

Up to now, little, if any, policy direction has been given to implementing educational technology in our schools, either from the Department of Education or elsewhere. A newly legislated position of Director of Technology under the Secretary of Education should help correct this oversight and allow education policy to influence how public schools will be connect to the NII.

Electronic networks, and the different methods of networking that are being created—whether over telephone or cable lines or a combination of the two—will bring up questions that we have never before had to address in ways in which we have never before had to address them. However, they also provide opportunities to address problems such as equity that have seemed intractable for so long.

But universal service promises to be a thorny issue. The history of regulation suggests that there may be difficulties ahead for the new services that are appearing. Regulation is recognized as necessary—because, particularly in systems such as telephone service, it is the reason for universal access—but, in this era of new services that thrive on competition, regulation also poses problems. Again, Mitch Kapor (1993) states:

> *Everyone has the right to telephone service, and local telephone service is inexpensively priced. Yet this universal service commitment has been achieved through a system of regulation that draws no praise and is in the process of being dismantled. Patricia Eckert, chair of the California Public Utilities Commission, has spoken of the co-dependency of regulators and the regulated. The cure for this addiction is the free market, but no one is promising that competition alone will insure that everyone who wants service can get it, or that if it is available, it will be affordable. Universal service is the baby that must not be thrown out with the bath water of a dysfunctional regulatory system. In truth, no one knows how to accomplish this yet. It is therefore imperative that, in the public policy debate about broadband networks and increasing competition in local phone and cable service, the right to service must be given priority. (p. 58)*

Despite the many voices calling for equitable and affordable access to the NII—from the President to individual students in schools throughout the country[5]—not everyone views universal access to the NII and the Internet as essential. Some voices are raised in support, while others dissent.

Consider the following:

- Vice-President Gore acknowledges that the information highway will be built, paid for, and funded by the private sector (Kapor, 1993, p. 55) Gore sees one of the roles of the federal government in this enterprise as stimulating a private system of free-flowing information conduits. The government will manage the transition to an information system in which any person wanting information will be able to choose among competing information providers at reasonable rates, and anyone who wants to form a business to deliver information will have the means of reaching customers.

- Illinois Lieutenant Governor Robert Kustra, a substitute speaker for Governor Jim Edgar at a meeting of the Du Page area business and government leaders called the East West Corporate Corridor Association, hailed "the creation of fiber optic networks to link poorer school districts with their more affluent, better-equipped neighbors" and rural schools with local community colleges. "I think that high tech . . . has the potential of solving the inequity problems and it's a far better solution from a business standpoint than to just throw more money at schools," Kustra said. (Presecky, 1993, p. 2)

- A front-page article in the Chicago Tribune suggests questions about how and whether the "so-called information superhighway" should be regulated. Some have suggested that it should be set up much like other services such as telephones, water, and electric power—in other words, available to all at a price, but within a range that makes it accessible to the many and not just the few.

  However, Andrew Barrett, a commissioner of the Federal Communications Commission (appointed by George Bush in 1989), is quoted as saying:

  > *Just as we have poor people today, just as we have homeless people today, just as we have jobless people today, we will have the information-rich and the information-poor . . . .*
  >
  > *I do not accept that everyone, because they have a telephone, should have interactive cable. I don't accept that as part of universal access. (Grady, 1993, p. 1)*

Gore sees one of the roles of the federal government in the development of the NII as stimulating a private system of free-flowing information conduits.

Equity issues in education, until now, have been considered almost intractable. Systemic reform is a goal of education. One aspect of systemic reform is providing equitable access and opportunity to participate in quality learning environments providing quality instruction and access to quality materials. As we have stated, the major shift in focus from teaching to learning means that students become knowledge users and teachers become facilitators of this development. It is absolutely essential that education has full access to the developing electronic networks in the most appropriate and affordable way for each school if equitable opportunity for a quality education is to be provided for all students.

Equity, Connectivity, and Interactivity

Connectivity and interactivity are two basic premises for using telecommunications and information technologies for systemic reform. Connectivity looks at the answer to the question of what the responsibility of private industry will be to provide access/services and reduced rates for information resources, electronic networks, and telecommunications facilities to social service agencies such as education. It is our belief that access to these systems and networks should be universal and must include schools, although some schools will need support to obtain this access. Equity in education can be addressed by guaranteeing access to these technologies at an affordable rate for all classrooms and by giving all students the opportunity to interact with all of the resources, materials, and data on these systems.

For education, universal access is paramount.

Even if market forces somehow resulted in universal access, the notion of interactivity would need to be separately addressed. If systemic reform is to occur in education, it is our view that the opportunity to interact electronically beyond the classroom to obtain data and information will be a leveler of education resources that does not now exist for the poor and the minority school populations in our country. We believe that all schools and classrooms at the entry level ought to have the ability (connectivity) to use proactively (interactivity) the developing information infrastructure.

A definition of interactivity comes from Mitchell Kapor, head of the Electronic Frontier Foundation based in Washington, D.C. Kapor (1993) believes that interactivity means that anyone can put information on a system and anyone can access that information. Kapor focuses on the idea that we need to institututionalize interactivity if it is to be a fundamental component of networking. Achieving this goal means more than limited content offered over unlimited channels. It means that the typical television viewer must become a producer as well as a consumer, actively choosing what will come across the television and when it will come across, based on his or her own choices, not on the programming decisions of the networks. Electronic interactivity taken to its highest point implies that any two points on the network are capable of acting on each other, able to send information as well as receive it.

Connectivity and interactivity are two key issues that must be considered in the development of an electronic network for education or in connecting the education system to existing electronic networks. For education, universal access is paramount. We must connect all schools and ensure that they can afford to use the system that connectivity will make available to them. Interactivity, on the other hand, provides environments that encourage the construction of knowledge on the part of the student and makes it possible for him or her to interact with resources, individuals, and information. Education policymakers must implement policies that reflect these goals. Kapor describes these policies in the following way:

> *The networks must be built as open systems intended to support the greatest possible diversity in:*
>
> *Access. Everyone should be able to connect.*
>
> *Content. Users should be able to determine the content of the system.*
>
> *Uses. People should be able to choose the roles they wish to play, whether as consumers, providers, or both.*

> *Architecture. Networks must be built as a series of inter-operable components with well-defined published interfaces, which permit maximum third-party competition.*
>
> *Protect free speech and privacy. Constitution protections of personal privacy and freedom of expression should be extended to the emerging networks. (Kapor, 1993, p. 94)*

An important caveat must be included here concerning the amount and type of access that is made available to younger users. It offers a challenge to educators and lawmakers to consider some important issues:

> *[F]or a nation obsessed with censorship, introducing children to the Internet is like waltzing in a mine field. The Internet is not a sterile playground, amusement park, or library, but a complex, multi-cultural world that includes international spies, common garden-variety hackers, hate mongers, binary pornography, subversive political literature, and "illegal" information concerning explosives, firearms, and the great satan of the 90s—drugs.*
>
> *How the United States' courts and educators respond to the rise of the Internet will shape the next generation into either cultural clones or adaptive, self-driven, critical thinkers able to function in a very different world . . . . (Strangelove, 1993, p. 21)*

Policymakers must enact policy and legislation that takes the needs and concerns of education into account, yet guarantees full, affordable participation for all schools in the developing NII.

For policymakers, providing an equitable education for all students is a key unresolved issue. But that issue, as noted above, must be balanced against concerns about what will be made available to students over the Internet and who will decide what that access will look like. Perhaps regional entities or consortia could develop an educational information infrastructure that would resolve this issue by putting into place a policy addressing what will be available over a regional information infrastructure for education. This issue is a thorny one and is discussed in the section on regional consortia.

It is our belief that the advances in telecommunications and information technologies allow us, for the first time, to provide the same opportunity to a quality education for all students. To avoid missing this opportunity, policymakers must enact policy and legislation that takes the needs and concerns of education into account, yet guarantees full, affordable participation for all schools in the developing NII.

Gore and Gutenberg

One very powerful way to get a message across to people is through a story. While we cannot offer a story, we can offer the following scenario:

> *A new technology has become available. It could make vast quantities of information accessible to great numbers of people, people who have never before been exposed to, much less been in the position to consider, the ideas that are suddenly within their reach. Some see great improvements in the quality of life resulting from this new technology; others great costs. Both see a portion of the reality which the new technology creates.*
>
> *The new technology will continue to develop with or without intervention. As a consequence, and because the technology will evolve and new versions proliferate, more and more people will come into contact with its product. What this contact will mean depends upon what kind of interaction takes place between the user and the product(s) of the technology. The question facing both groups, however, is how to make the most of this new technology now that it exists.*

BEST COPY AVAILABLE

The preceding scenario describes the situation encountered with the advent of the printing press and moveable type and applies equally to the development of electronic networking capabilities today.

The effects of the printing press were felt throughout society. Society took decades, even centuries, to adjust to the changes wrought by this technology. It exposed vast new audiences to information that previously had been seen and analyzed by only a few. The same experience will occur in our day and age as students, teachers, and the general public gain access to databases and other forms of information that at one time only scientists and researchers had used.

These policy choices will guide our use of telecommunications and information technologies in educational settings and determine the benefits that we derive or the costs that we endure.

This very situation is being enacted in several education arenas with respect to telecommunications, information technologies, and networked systems: so much information suddenly in the hands of so many people and so many decisions to be made about what to do with it—and especially how to apply it to enhance teaching and learning. A number of authorities at the federal, state, and local levels are charged with making decisions with respect to information technologies and how these technologies will be used in education. These policy choices will guide our use of telecommunications and information technologies in educational settings and determine the benefits that we derive or the costs that we endure. The NII will be built. The role that education will play in developing equitable policies to allow all students to use the NII is not so definitive.

Yet, we must be careful. The printing press itself had an impact on society beyond any effect imagined by Gutenberg. As Neil Postman (1992) points out:

> *Unforseen consequences stand in the way of all those who think they see clearly the direction in which a new technology will take us. Not even those who invent a technology can be assumed to be reliable prophets, as Thamus warned. Gutenberg, for example, was by all accounts a devout Catholic who would have been horrified to hear that accursed heretic Luther describe printing as "God's highest act of grace, whereby the business of the Gospel is driven forward." Luther understood, as Gutenberg did not, that the mass-produced book, by placing the Word of God on every kitchen table, made each Christian his own theologian . . . . In the struggle between unity and diversity of religious belief, the press favored the latter, and we can assume that this possibility never occurred to Gutenberg. (p. 15)*

Postman goes on to discuss the various methods that were employed in trying to control the flow of information initiated by the invention of the printing press, from innovations in the format of the machine-made book to the establishment of the modern school. In considering this latter development, Postman observes:

> *There were several reasons for the rapid growth of the common school, but none was more obvious than that it was a necessary response to the anxieties and confusion aroused by information on the loose. The invention of what is called a curriculum was a logical step toward organizing, limiting, and discriminating among available sources of information. (p. 63)*

The NII, as envisioned by Vice-President Gore, is also faced with a number of unknowns and with decisions to be made as to how to control the flow of information. It is most likely that we will have to accommodate the technology rather than assuming that the technology will accommodate us. However, like Luther, we can try to understand its true implications. By doing so, we can guide and influence the impact that it will have.

Technology Is Not the Answer to Education's Problems

Even with the problems associated with the "low-end" technology and lack of curricular emphasis that Channel One espouses, schools want technology and they enter into agreements of purchase or lease without necessarily having a clear plan for technology use in the curriculum. Many schools and districts seem to assume that technology, irrespective of curricular issues, is sufficient. We want to emphasize strongly that technology alone is not the answer to the problems of education. Indeed, we cannot emphasize enough that technology must be planned for within the context of curriculum goals, student achievement, and affordability, and that such planning must be done slowly. It is our belief that only after schools or districts have clearly stated their curricular outcome objectives can teacher teams take on the responsibility for planning, developing, implementing, and adapting telecommunications and information technologies with strategies to enhance student learning.

Multiple technologies that can be applied in multiple settings for multiple purposes are available—there is no single right technology. A school can purchase computers, scanners, printers, videodisc players, CD-ROM players, camcorders, editing equipment, modems, television sets, satellite dishes, and access to several telecommunications options. However, if teachers are not trained, if usage fees for telephone lines and access to information resources are not included in the budget, and if the technologies do not meet curricular needs, then the school is probably wasting its time and money.

At its best, technology can be used as a tool to help teachers change and enhance what they do in the classroom. It offers this potential because it gives access to vast amounts of information. In addition, technology removes barriers of time and distance, permitting students from rural communities or from communities without adequate resources to access experts and information sources to the same extent as more affluent areas. Technology appropriately planned for and integrated can become a very important tool in addressing growing inequities of quality resources and quality learning experiences for all students. But, by itself, technology will not solve these problems. As Herman (1993) reminds us:

> *[I]t is not the technology in and of itself, but the way in which the technology is used that is likely to influence student outcomes. (Herman, 1993, p. 131)*

We acknowledge that, because of funding and other factors, states and districts are at different levels in their ability to accommodate various types of telecommunications and information technologies. Despite this situation, however, we recommend the implementation of technologies that are interactive and that promote engaged learning, because these technologies support the types of strategies that will help students master the challenging new state content standards.

Table 1 represents the possible choices suggested by the intersection of technology and learning. Technologies can be either passive or interactive and can encourage either engaged or passive learning. Each of the cells in Table 1 illustrates the different combinations of either engaged or passive learning or interactive or passive learning implied by this differentiation, as well as the kinds of activities attached to these combinations that support different curricular goals.

Technologies can be either passive or interactive and can encourage either engaged or passive learning.

For instance, the cell in the upper left corner represents a high level of technology that supports a high level of learning. Some examples might include the CoVis and Jasper Series projects described earlier. The cell in the upper right corner indicates that passive learning might also occur with interactive technologies. Examples of activities for this cell might include activities such as those that are frequently a part of computer-aided instruction (CAI). The cell labeled engaged learning/passive technology implies that engaged learning also can occur with more passive technologies, such as the videotape technology used in the activities included in the proposal developed by Bob Beck et al. Finally, the last cell, labeled passive learning/passive technology might suggest technologies such as films and television, when used in their most traditional way.

Engaged learning also can occur with more passive technologies.

For the content represented in Table 1, the authors acknowledge Nowakowski and refer readers to *Toward Redefining Technology Effectiveness in Education* (Jones, Valdez, Nowakowski, & Rasmussen, 1994).

Table 1

Learning and Technology Combinations		
	Engaged Learning	Passive Learning
Interactive Technology	Engaged Learning Interactive Technology *Examples: CoVis; Jasper Series*	Passive Learning Interactive Technology *Examples: computer-aided instruction*
Passive Technology	Engaged Learning Passive Technology *Examples: Activities outlined in proposal submitted by Bob Beck et al.*	Passive Learning Passive Technology Examples: films, videotapes (when used in the most traditional way)

NII Implications for Education

As clearly stated and supported in Jonathan Kozol's book, *Savage Inequalities*, schools establish invidious distinctions that create different standards for different populations of students—in particular, the poor and minority populations. What happens is

> *[t]he evolution of two parallel curricula, one for urban and one for suburban schools, [underlining] the differences in what is felt to be appropriate to different kinds of children and to socially distinct communities . . . . What is considered right for children in . . . inner-city schools becomes self-evident to anyone who sees the course of study in such schools. Many urban high school students do not study math but "business math"—essentially, a very elemental level of bookkeeping. Job-specific courses such as "cosmetology" (hairdressing, manicures), which would be viewed as insults by suburban parents, are a common item in the segregated high schools and are seen as realistic preparation for the adult roles that 16-year-old black girls may expect to fill. (Kozol, 1991, pp. 75-76)*

Setting clear, high expectations for all students will make those expectations clear to parents, students, teachers, and administrators.

These students are held to lower standards, and, of course, they strive to meet those lower standards, never realizing that they are receiving an inferior education with fewer opportunities for success as they move through the system. Setting clear, high expectations for all students will make those expectations clear to parents, students, teachers, and administrators. These expectations are not different for different populations—they are high standards for all students. If we are ever to achieve equity in our education system, then a good starting place is an agreement about what the expectations are for all students.

The NII will provide opportunities to connect all of our classrooms and schools to a network that will allow students, teachers, and administrators, as well as policymakers in education, to use telecommunications and information technologies to access information in ways that will transform the way teachers teach, students learn, and school management is operated. More important, it can become a very important tool for developing curricula that will reflect what we know about teaching and learning and that is directly tied to the standards developed in each curricular area.

The Administration's and most states' efforts in implementing systemic education reform based on restructuring of the schools to meet higher standards for all students could be very greatly supported through the integrating and networking opportunities that the NII will afford. One possible implication of this type of networking capability will be the development of new roles for teachers and students that are highly interactive, motivating, and rich. In order for restructuring to occur in the instructional and professional development areas, educators need to be clear about how they will use the telecommunications and information technologies capabilities to enhance learning and further their professional development.

Schools Want Technology

Despite the above facts and the reasons that may or may not account for the dearth of telecommunications and information technologies available in schools, it is evident that schools want the technology. One example of school demand is the response to the Whittle Communications, Inc. Channel One program. Whittle Communications Education Network was able to provide entry-level technology to more than 12,000 schools in less than two years in exchange for the schools' viewing the Channel One Program. In the seven-state north central region alone (Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin)

2,933 schools have a contract with Whittle Communications. That number represents a penetration of eligible public and private schools from a low of 18% in Wisconsin to a high of 64% in Ohio.

Whittle purchases and installs a KU band fixed satellite dish, television monitors, and a central video recorder for each building. In addition to the technology, the network offers three channels: Channel One, a 12-minute news program, including two minutes of paid advertising; The Classroom Channel, an instructional support channel operated by Pacific Mountain Network, a consortium of 43 public television stations in the Western United States; and The Educator's Channel, a professional development channel.

The debate surrounding Channel One has centered around the use of advertising in education, which is seen by Channel One's detractors as taking unfair advantage of students and providing no protection against commercial exploitation. It is fair to say that the philosophical debate taking place in state capitals and in Washington, D.C., on the harm or value of in-school advertising has had little significant impact on the decision-making process at most schools. Whatever the outcome of the debate, as Dan Schultz of the Michigan Department of Education observes:

> *It is fair to say that Whittle Communications has pushed the technology agenda forward in education, more than any other movement or organization since the introduction of public television in the 1950s.*

The following chart shows the significant penetration of Channel One programming in the north central region of the United States:

Table 2

Channel One Schools by State in the North Central Region

State	Number	Percentage
Illinois	404	39
Indiana	383	56
Iowa	225	56
Michigan	705	56
Minnesota	130	24
Ohio	975	64
Wisconsin	111	18

Key: Numbers listed represent the number of schools in each state that have signed contracts with Whittle Communications.
Percentages listed represent Whittle Communications' penetration of eligible public and private secondary schools in each state.
Source: Whittle Communications 11,927 Schools, July 1993.

Should the New Telecommunications and Electronic Capabilities Be Used to Support the Old Paradigm, or Should They Be Used to Help Implement a New Paradigm?

Using Technology to Achieve Higher Standards

Schools, districts, and states are developing higher standards or expectations for what they want their students to know and be able to do. Explicitly defining what students are expected to achieve will lead to understanding the necessary changes that will have to occur within the system to create the conditions for higher achievement.

The current focus on discrete skills results in no large measure from the organization of the school day.

The question comes down to one of deciding what we want education to accomplish. One might argue that in the past we differentiated between educating a student and training him or her for the workplace. For the most part, students in public schools received an education that prepared them for work in industry and factories. Time in school, particularly in high schools, was divided into increments so that it imitated shift work, moving students from task to task at predetermined times. Students were subtly equipped to perform tasks that required little in the way of reflection and analysis. Rote memorization and mechanical tasks ruled. It was the students who moved on to college who received a grounding in subject matter that asked students to synthesize information and formulate questions. These students were the ones who moved into the professions.

Today, we recognize that all students must have an education that resembles the latter description rather than the former. We are calling on all students to master higher-order thinking skills, because those skills are the ones that they will need in the workplace.

The current focus on discrete skills results in no large measure from the organization of the school day. Given the amount and range of information teachers must impart over the course of a day, by design or default, the primary method of instruction has tended toward lecture and drill and practice. Larry Cuban (1986) outlines the situation in the following way:

> *[T]he classroom [is a] crucible where conflicting cultural, community, and organization imperatives mix, creating the elements of . . . paradox. In the books they use, the curricula they follow, their pedagogical choices, and the goals they pledge to achieve, teachers cope with contradictory social messages. Embedded in the policies, work routines, and expectations signaled by administrators, school boards, media, and parents is a set of contradictory notions:*
>
> > *Socialize all children, yet nourish each child's individual creativity.*
> >
> > *Teach the best that the past has to offer, but insure that each child possesses practical skills marketable in the community.*
> >
> > *Demand obedience to authority, but encourage individual children to think and question.*
> >
> > *Cultivate cooperation, but prepare children to compete.*
>
> *Coping with these conflicting messages within the hierarchical structures in which teachers must work drives them to construct*

> *a practical pedagogy, permitting them to complete a hectic five-hour instructional day. Reduced to classroom scale, teacher-invented solutions to these contradictions often have concentrated on transferring knowledge, skills, and values to students through the teacher lecturing and questioning while the student listens and answers, and through reading textbooks and performing chalkboard and other in-class work. This pedagogy worked. It has provided continuity between generations while presumably laying the foundation for individual change in children. Yet shifting public expectations for what schools should achieve (e.g., high test scores) leaves teachers consistently open to attack. (pp. 2-3)*

Using technologies effectively in education requires shifting our focus from teaching to learning.

Supporting traditional education or the status quo will not be sufficient to meet the higher standards that we are expecting from students. In order to help students meet these higher standards, schools and districts will find that systemic school reform is imperative. In a recent report entitled, *Prisoners of Time*, issued in May 1994, the National Education Commission on Time and Learning, using time as a variable, studied schools that had extended their day, extended their school year, adopted year-round schooling (either single-track or multi-track), reorganized their day, or used some combination of the above approaches. As Alan November (1992) observes:

> *it does not make any sense to me to add technology to a 45-minute period when we should not have 45-minute periods in the first place. (p. 20)*

Using technologies effectively in education requires shifting our focus from teaching to learning, with more and more of the learning coming under the control of the learner. Reformers and cognitive learning researchers advocate active—not passive—learning, learning tasks and apprenticeships that rely on authentic relevant problem solving, sustained and challenging work in individualized settings, collaborative grouping, an emphasis on higher-order thinking skills and complex problem solving, project-based and thematic syntheses of subject matter, greater student involvement and students' control over their own learning (Brown, Collins, & Duguid, 1989; Collins, 1991; Scardamalia & Bereiter, 1991). A learning environment in this sense emphasizes the following qualities:

- Interaction rather than isolation: Knowledge and expertise develop when students have a chance to interact with resources that include their peers, teachers, experts from various fields, and print and electronic text and databases.
- Individual learning styles. Learners are most successful when they can use a learning style suited to their needs.
- Adequate professional development: In order to implement and adapt alternative learning strategies, teachers must be helped to become models of active learning.
- Learning as the main consideration in decision-making: Curriculum planning and scheduling should focus on using time according to learning needs, rather than on conforming learning to divisions of time.
- Cognitive research: Students learn best when the tasks involve meaningful contexts, activities, and problems so that they can actively construct their own knowledge and develop the ability to apply what they learn to new situations.
- Explicitly stated performance outcomes: Accountability can be ensured if progress on assessment measures reflects skills learned in classroom activities.

It is our belief that telecommunications and information technologies will play an important role in reforming how we educate our students and how we train our teachers. As we apply technology to learning tasks for students, we will change the way teachers teach and the way students learn. Different technologies will effect these changes in different ways. One example, the Jasper Series, from the Cognition and Technology Group Technology Group at Vanderbilt (CTGV) (1992), is particularly effective at focusing student activities on generative learning—that is, on being able to synthesize and make connections to prior knowledge and other pieces of information because of their relevance to the problem at hand. This video-based, quasi-case study approach affords students the opportunity to:

> *[generate] subgoals, [identify] relevant information, [cooperate] with others in order to plan and solve complex problems, [discuss] the advantages and disadvantages of possible solutions, and [compare] perspectives by pointing out and explaining interesting events. (p. 296)*

Other examples provide similar experiences. For instance, the Image Processing for Teaching (IPT) project at the University of Arizona uses imaging technology to introduce students to mathematical concepts. One of the strengths of this technology is that:

> *image manipulation can be started without much understanding of the underlying mathematics, [enabling] a student [to] have an authentic scientific inquiry or discovery experience without reliance on traditional (language or math) coded methods of teaching. This process allows IPT to reach visual learners and non-traditional populations. Nevertheless, image processing is at its base a mathematical operation. Students may not be thinking about mathematics in the beginning, but as they manipulate images, they start thinking in mathematical terms, and understanding concepts such as arrays, slope, and intercept. (Gomez, 1994, p. 9)]*

The Collaboratory Notebook of the NSF-funded Collaborative Visualization Project (CoVis) emphasizes the student's role in constructing his or her own knowledge. In this case,

> *[t]he Collaboratory Notebook encourages students to express their thoughts and actions explicitly in the context of scientific inquiry. It helps them to organize their knowledge and identify the gaps in their understanding. In this way, the Collaboratory Notebook provides a window for teachers into the inquiry efforts of their students. This window can help them to provide better focused guidance and to assess student progress. (Gomez, 1994, p. 15)*

It is our belief that telecommunications and information technologies will play an important role in reforming how we educate our students and how we train our teachers.

Systemic reform thus implies a shift from the status quo to dramatic transformations in curriculum and instructional practices, such as the above-mentioned examples. Technology is an integral component of these new approaches, although it can take many different forms. The above-mentioned examples demonstrate the kinds of learning environments that can be produced using sophisticated technologies, especially when they are coupled with sufficient resources and a well-defined process.

Bert C. Roberts, Jr., Chairman and Chief Executive Officer, MCI Communications Corporation, creates a vision of how telecommunications and information technologies can change education:

> *Perhaps one of the biggest beneficiaries of the multimedia revolution will be our educational system. Multimedia may help solve our nation's education crisis, transforming the way students learn, and providing near universal access to multimedia classrooms. At the same time, regularly updated multi-*

> *media databases will create uniformly high standards of learning—and help young learners transcend the barriers of geographic locale. Every child will have access to quality information and have a chance to learn. (Roberts, 1993)*

The technology is at hand to enable students to receive instruction that meets their capabilities, interests, and current level of knowledge and to restructure the entire school system and school day. The same technology can analyze student inputs as they solve problems, allowing the teacher to evaluate each child's progress as he or she proceeds at his or her own pace. The appropriate use of technology can accomplish routine administrative and teaching activities more efficiently. With the support of technology, teachers can provide individualized help and stimulate student interest, interaction, and creativity. Telecommunications and information technologies can extend learning by connecting students with resources and people beyond the limitations of an individual classroom, school, district, state, or country.

Investing in telecommunications and information technology is being seen by more and more policymakers and educators as a tool to help achieve school reform.

Investing in telecommunications and information technology is being seen by more and more policymakers and educators as a tool to help achieve school reform. Technology is also viewed as a way to help implement a new paradigm of learning based on inquiry. In this paradigm, the learner actively manipulates information in class in a variety of contexts from a number of different resources in order to solve meaningful and relevant problems. Students thus are actively creating their own knowledge, as opposed to sitting passively at a desk with little opportunity to interact with information in a meaningful and relevant context (Barron & Goldman, 1993; Means, 1994; Beck et al., 1991; Mageau, 1992; Cognition and Technology Group, 1992). Teachers are seen as tutors, guides, facilitators, and managers who provide a structure to the learning, share their own knowledge and experience, and provide students with individualized help (Gomez, 1994).

How Can Technology Best Be Adapted to Our Schools to Support Change in the K-12 Curriculum?

Effectiveness of Technology

Technology can address the individualized needs of students and break down the traditional barriers of geography that limit access to quality instruction in many curricular areas, providing content in an affordable way that would otherwise be unobtainable for schools or districts; technology potentially can make it possible for students to access information from all over the world. It can facilitate the teaching and learning process and can be used to provide professional development in a cost-effective manner and allows teachers to interact with one another on an as-needed basis or access the latest research and best practices right from their classrooms when they want it. As a tool, technology can accomplish a range of activities, from instruction to management to assessment. Fletcher (1990, 1992) conducted a series of analyses for the military comparing the use of technology versus conventional instruction costs and generally found a cost-benefit savings, particularly in terms of student time-on-task.

The problem has been that the benefits of investing in new information technology cannot be clearly demonstrated. Investing in the new technologies so far has not yielded clear results that inspire confidence among hard-headed politicians and civil servants. A major concern with respect to the effects of using technology in the classroom is that generally when we attempt to assess results in the use of technology in this country, we use a pretest/posttest paradigm of student achievement as measured by standardized tests. One criticism of this type of assessment is that what students learn cannot be tested by the types of standardized assessments we use.

Herman (1993) argues that attempts to find significant differences when using technology on student learning, workforce readiness, and teacher productivity have failed—not because there are no significant differences, but because of the methodologies and tools we have used to try to measure the differences. The biggest problem, as Herman notes, is that a standard experimental design assumes a uniform independent variable. Yet many schools encourage teachers to explore the use of technology and adapt it to fit their curricular needs. Often different technologies are employed across classrooms and teachers, or the same technologies are used in different ways. Very often it is an instructional assistant employing the technology. Hence, an operational definition of a program treatment is often impossible to identify. Without a standard treatment, using standard outcome measures is mostly inapplicable and useless.

To be used effectively, technology must be viewed as an essential part of the curriculum and not something that is just added on as funds become available. As an integrated part of the curriculum, we assume that the choice of telecommunications and information technologies is based on clear expectations of what students should know and be able to do. This choice also requires that we define what teachers will need to know and be able to do in order to provide structure for students that will guide—not prescribe—their learning. The intent is to use technology as a tool to promote well-articulated goals for learning and for teaching.

For instance, one goal may be to design and use technology in such a way that it promotes the generative acquisition and use of knowledge. By generative we mean, as referenced by the Cognition and Technology Group at Vanderbilt (1992), that knowledge must be

> *called upon over and over again as ways to link, interpret, and explain new information. (p. 293)*

To be used effectively, technology must be viewed as an essential part of the curriculum and not something that is just added on as funds become available.

The Jasper Series uses technology in just this way. It seeks to create an interactive environment to sustain attention and interest and foster learning. It is the interactive nature of the material that contributes to learning. The Jasper Series very deliberately set out to create such an environment:

> *Our attempt to create instructional materials that afford generative-learning activities has been guided by the following seven basic design principles: video-based format, narrative with realistic problems (rather than a lecture on video), generative format (i.e., students must generate the subproblems to be solved at the end of each story), embedded data design (i.e., all of the data needed to solve the problems are in the video), problem complexity (i.e., each adventure involves a problem of at least 14 steps), pairs of related adventures (in order to discuss issues of transfer), and links across the curriculum. (Cognition and Technology Group, 1992, p. 297)*

This approach makes it possible to provide opportunities for the principles and formulas used in one problem to be applied to similar problems under different conditions. These alternatives can take the form of analog or extension problems. Analog problems take the same situation presented in the original, but change the parameters, thus changing the elements that will be plugged into the formula and perhaps the solution that is recommended. Extension problems, on the other hand, ask students to apply the principles from the original problem to the conditions and circumstances faced by scientists or historical figures in real-world applications. In the Jasper Series, the teachers, as well as the students, benefited:

> *Teachers also emphasized that the Jasper adventures suggested a variety of hands-on activities that were engaging to students. For example, a number of classes used information from the business plan adventures to generate enough money to take an educational trip—and they used their trip planning skills to plan it. These types of extension activities represent our ultimate goal for the Jasper series. The videodisc adventures are an intermediate step; they make it easier for teachers to begin to experiment with new approaches to instruction (e.g., ones that emphasize projects rather than an array of decontextualized drills), and they provide a common ground for further discussion by students, teachers, and parents. (Cognition and Technology Group, 1992, p. 308)*

In another experiment, the Image Processing for Teaching (IPT) project at the University of Arizona, image processing is the technology application used in the classroom. It also allows students to investigate problems and come up with solutions based on those investigations. According to the Digital Libraries proposal submitted by Northwestern University and the University of New Mexico (Gomez, 1994) to the National Science Foundation (NSF):

> *Preliminary indications show image processing to be an effective and motivating way for students to study the application of science and mathematics to "real world" applications, as represented by digital imagery. The use of image processing is also an effective method with which to engage students in inquiry and discovery learning. Since the inquiry process is at the core of what is exciting about science, using computers in this way is both intuitive and potentially very productive in inquiry-based learning. (Gomez, 1994, p. 8)*

The Collaborative Visualization (CoVis) project, on the other hand, concentrates on connecting various learning communities, such as students, teachers, and scientific and other professionals. This project is aimed at:

> *[deriving] insights into effective educational reform based on constructivist pedagogy and next-generation communications and computing technologies. (Gomez, 1994, p. 1)*

Different ways in which technology can be used to support educational reform include activities that focus on tutorial learning, exploratory learning, applications as tools for learning and teaching, and communication.

These examples show different ways in which technology can be used to support educational reform. They include activities that focus on tutorial learning, exploratory learning, applications as tools for learning and teaching, and communication. They also suggest ways to manage the changes in teaching and classroom environment resulting from thoughtful/planned school reform. Means et al. (1992) describes the effect in the following way:

> *[The] literature shows, in brief . . . that when used in ways that are compatible with the student learning model [we propose], technology supports exactly the kinds of changes in content, roles, organizational climate, and affect that are at the heart of the reform movement. (p. 12)*

Other studies also have reported on the benefits derived from these approaches. Herman (1993) refers to the positive effects of tutorial learning, or computer-aided instruction (CAI), while the Jasper Series highlights improvements in communication (Cognition and Technology Group, 1992).

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How Will These Information Technologies Affect the Way Teachers Teach and Students Learn?

We mentioned earlier that technology will change the way teachers teach and the way learners learn. What does that mean? Do we really know how teachers teach now and how learners learn?

We could answer the question by consulting the research that exists on learning. To simplify that body of research tremendously, the results do suggest that students truly internalize concepts when they have a chance to be actively involved with what they are learning—manipulating data, asking questions, consulting with peers and experts—which argues against the approach of having the teacher standing in front of the room dispensing knowledge (Beck et al., 1991; Cognition and Technology Group, 1992; Gomez, 1994).

How the introduction of technology changes how information is presented and how teachers and students interact with it is being researched. The findings show that technology DOES militate against the "teacher as lecturer" approach. It DOES invite the active participation of students. The Jasper Series, the discussion of integrated learning systems, the CoVis project, and IPT referenced earlier are but some examples of ways in which technology engages students, requiring them to generate their own questions in working through the solution to a problem, rather than waiting for the teacher to do so.

Teacher training is a key component of ensuring the success of these programs. In each of these cases, the developers and researchers keep in frequent contact with the teachers and provide extensive support. These programs have done as well as they have because they have "buy-in" from the teachers and because time and energy is expended to help them become well versed in the goals, objectives, and methodology of the process.

We have argued that systemic change in education is a goal and systemic reform is much less likely to occur without applying telecommunications and information technologies to education. The next questions we must ask ourselves then are what the links are and what technologies have been shown to foster aspects of systemic change.

We must ask ourselves what technologies have been shown to foster aspects of systemic change.

Supporting Education Reform With Technology

Means et al. (1993) states that education reform includes the following features:

- Heterogeneous grouping. In other words, having students work with other students who are not exactly like them—either in terms of intellectual capacity or academic achievement.
- Performance-based assessment. Requiring students to show what they have learned by conducting an experiment or producing a report, among other activities, rather than by simply being able to score well on a multiple-choice paper-and-pencil exam.
- Authentic and multidisciplinary tasks. The work students do in the classroom should reflect real-world activities such as using the same scientific inquiry method a scientist would use in conducting an experiment.
- Collaborative work. Work that takes place in the workplace often involves a team effort. Classroom activities should give students a chance to learn how to work together on a task, rather than emphasizing a strictly independent approach.

- Interactive modes of instruction. Interactive instruction makes it possible for the student to consult with experts and peers, as well as the teacher, in investigating a problem or completing a task.

- Student exploration. A student who explores takes an active part in learning, answering questions and posing new ones, rather than merely absorbing what is presented.

- Teacher as facilitator. In this sense, the teacher encourages and guides students in their explorations rather than holding the position of sole authority. (adapted from Means et al., (1992), pp. 49-50)

We are recognizing that the student is the client and that we are identifying the most effective means by which to meet his or her needs.

Certain technologies have been found effective in implementing each of these features.[6] For instance, Hypermedia and Networks and Related Applications provide support for every education reform feature. Microworlds and Simulations; Multimedia Tools and Approaches; and Videocameras and VCRs each support six of the seven features. Two technologies—Videodisc and CD-ROM and Word Processors/Intelligent Writing Tools—allow for five of the seven features. Finally Electronic Databases and Microcomputer-Based Labs make it possible to implement four of the reforms. Therefore, out of thirteen possible technologies, nine encourage the majority of the education reform measures.

In addition, interactive multimedia software is seen by many educators as a tool for reaching these goals and for restructuring American education. Programs that use this software are inherently interesting, but, more important, they are also powerful and complex enough to support sustained learning in the classroom. A recent article in *Business Week*, "The Learning Revolution," includes quotes from a number of different individuals who are using this same technology in a number of different ways. All of them, however, believe in the same efficacy:

- Donovan Merck, manager of the Education Technology Office for the Department of Education in California states: "We want curriculum reform, and we see no other way to do it than multimedia."

- Warren Buckleitner, a former school teacher and current editor of the newsletter *Children's Software Review*, says that multimedia is a more effective way to learn because "[t]he computer gives control back to the kids. They are in control of their own learning."

- Roger Schank, director of the Institute of Learning Sciences at Northwestern University, believes that interactive training systems are important because "we need a way to economically provide individualized instruction . . . . Computers provide that economy." [*Business Week* (1994), p. 82]

Systemic education reform must continue to build off of these strengths and forge these connections. In doing so, we are recognizing that the student is the client and that we are identifying the most effective means by which to meet his or her needs. Those needs include helping students to develop skills in constructing their own knowledge and helping to prepare them for the workforce of the future-and that future is today.

The National Education Goals and the developing national education standards are expected to drive the reform agenda of the 1990s, focusing on a very different conception of what students should know and be able to do, how people learn, and, correspondingly, how schools and school systems should be organized. This reform agenda implies a systemic effort that will change the organization and structure of schools and will dramatically change what teachers teach and how students learn. How to achieve this reform is still a question. The new classroom will give students greater responsibility for their learning, where the teacher acts as a facilitator and the classroom reflects a community of learners, rather than individuals working in isolation. Technology will be an integral part of this structure. What we have tried to emphasize in describing these changes is that the new roles and activities, when linked with ongoing support for the teacher, will provide the greatest likelihood of achieving systemic reform and the national education goals.

Classrooms can be reinvented with the aid of technology, making inquiry-based learning the focal point of these settings.

In this model, teachers will guide students through individual and collaborative activities that encourage inquiry and the independent construction of knowledge by students. They will use technology as a part of the inquiry process, which is the approach taken by projects such as the Jasper Series and IPT. Although based on different technologies—video in the former and imaging in the latter—inquiry and the independent construction of knowledge figure prominently in the applications themselves. The focus will be on developing an attitude of continuous learning that will lead, encourage, and support teachers, support staff, and administrators to learn continually and improve upon what they know and what they are capable of doing. As results from an evaluation of the IPT Project revealed:

> *The participating teachers [became] acculturated to the social and intellectual process of scientific inquiry. Teachers' repeated comment on this point show their increased capabilities for incorporating such reform into their teaching. (Gomez, 1994, p. 11)*

Classrooms can be reinvented with the aid of technology, making inquiry-based learning the focal point of these settings. The following excerpt from a piece created here at NCREL suggests what one learning environment might look like:[7]

Life in the Classroom: A Scenario

. . . Knowing that the 10th grade science curriculum includes a sequence on the study of atmospheric science, Ms. Cary began her preparation by taking part in an interactive teleconference with the original testbed collaborators. These individuals, representing both practitioners and researchers, shared with her their experiences in piloting the program with groups of students similar to those in her classroom. The testbed's connection with the NSF assures her that the program of study conforms to the existing national standards in mathematics and science, as identified by the collaborative mathematics and science education project under the direction of the regional educational laboratories.

After the teleconference, and having accessed the relevant curriculum materials through a single network interface that includes other science and mathematics data bases, Ms. Cary is ready to have her students begin their own course of study. One of the areas that can be covered through the curriculum involves the short-term and long-term effects on atmospheric conditions after major volcanic eruptions. Although she wants her students to primarily investigate these direct results, she also wants them to attempt to extrapolate how similar, though man-made, conditions might mimic or exacerbate atmospheric events that are due to natural disasters.

Working in groups of four, the students begin their study by searching out several scientists who study phenomena of the type identified. Each group contacts one scientist via email, and by using the interactive video capabilities available at the school, and works with him/her to create a visual representation of the atmospheric changes that occur when a volcano erupts. The scientists also provide the students with raw data and statistics drawn from their own experiments, along with references to journal articles that explain the process in additional detail. With this information in hand, *the entire class then participates in a virtual-reality program that recreates the aftermath of such an explosion.*

. . . —all through ordinary applications of a range of technologies that are now common-place in schools throughout the nation.

Who Will Pay for this Electronic Connectivity?

The agencies and authorities responsible for making decisions with respect to education policy at the federal, state, and local levels are engaged in a debate about key questions concerning telecommunications and education and information technologies and education. The following are three of the most salient questions in this debate:

1. If the private sector will be paying for the NII, then what kinds of regulatory policies need to be promulgated and legislated, if necessary, in order to encourage investment from the private sector, partnering from the private sector, or subsidizing from the private sector to ensure that the NII goes to each classroom?
2. What kind of short-term planning needs to be considered and what kind of long-term planning needs to be institutionalized at the state and district level to ensure that curriculum determines technology choices rather than the other way around?
3. What is the best way to invest in telecommunications and information technologies for schools; what kinds of public-private ventures ought to be considered at the federal, regional, state, and local levels?

Educators must view themselves as a potentially huge audience or market for instructional technologies and use this leverage to influence the production of content that meets their specific needs as well as ensure that the NII carries enough bandwidth for their specific interests. The education system in a state or a region must influence the state legislature, the governor's office, and the state regulatory agencies to ensure full access for all schools to telecommunications services. Without a regional presence to influence telecommunications policy, education's voice may not be heard. This issue will be addressed in the section on regionality in this paper.

Educators must view themselves as a potentially huge audience or market for instructional technologies and use this leverage to influence the production of content that meets their specific needs.

Will Ma Bell Connect the Schools?

While the Baby Bells are ideally positioned to undertake the task of "wiring America," providing local service to most of the country, their history as regulatory entities leads them to seek a loosening of restrictions—allowing them to garner the profits that competition would offer.

The large telephone companies favor deregulation. They seek to create incentives for private investment in the infrastructure and to restrict the government's role. What it amounts to is

> *. . . deciding how to introduce competition into such a highly regulated industry [which] is proving very tricky indeed. 'What regulators are increasingly becoming,' says William H. Read, Southern Bell Professor of Communications Policy at Georgia Tech, 'are referees among vested interests such as telephone and cable companies. And they're having a harder and harder time determining what the public interest should be.' (Fulton & Newman, 1993, p. 29)*

In countering the concerns voiced by the Baby Bells, their critics point to two monopolistic advantages that the telephone companies hold, namely, control of the telephone switching equipment and the local "rate base." Part of the reason for the difficulties that exist in trying to disentangle the interests of regulators and "regulatees" is captured by Larry Toll, U.S. West's chief lobbyist in Iowa:

> *They are a customer of ours; they are a competitor of ours. They are a supplier of ours, in terms of public service. And they regulate us. (Fulton & Newman, 1993, p. 31)*

We believe that no one entity will end up building America's telecommunications highway. Who builds will depend on the market and area to be served. For instance,

> *in densely populated, prosperous business centers, the regulatory trade-off may be well worth the price: The market will be strong enough to keep competitive forces in motion. In other cases, it may well be that the Baby Bells will be the only entities strong enough to make the capital investment required in a particular area. And in rural areas and inner cities, the government may have to make direct investments and abolish the system of internal subsidies that has tied the Baby Bells and the public interest together for generations. (Fulton & Newman, 1993, p. 31)*

We believe that no one entity will end up building America's telecommunications highway. Who builds will depend on the market and area to be served.

Putting the technology into place means being able to pay for it. All students should benefit from any technology that is purchased. It is possible to guarantee that this situation occurs even if some technology is bought using federal money targeted for a specific population, such as Chapter 1 funds. As Lisa Brandes (1994) points out:

> *Most federal programs allow other students to use equipment and instructional materials purchased under the program—if, as the Chapter 1 flexibility guidelines put it, "all eligible students have participated to the fullest extent, and participation by non-eligible students will not reduce the useful life of the equipment or materials." (p. 12)*

Getting the technology into the school and the classroom is the first step in realizing these benefits. Funding may be the key:

> *Creative combinations of funding sources might mean the difference between having new instructional technologies now and waiting several years. (Brandes, 1994, p. 12)*

We strongly believe that no systemic change will take place in our schools without the application of telecommunications and information technologies to the education process. Technology and telecommunications systems will become the means for providing the education system with the tools to address systemic reform.

Summary of Section One

It is the position of this paper that if systemic school reform in this country is to succeed it will only do so with the application of telecommunications and information technologies at the classroom level with a simultaneous focus on sustained professional development for teachers.

Supporting traditional education or the status quo will no longer be sufficient if we are to enable our students to meet the challenging state content standards that are under development as well as the national content standards that are being identified by various national professional organizations. In order to help students meet these higher standards, schools and districts will find that it is imperative for school reform to occur. However, school reform efforts have been underway for at least a decade and the results have been anything but promising.

One of the major flaws in our past attempts to improve K-12 education has been our piecemeal approach to school improvement. As Saul Rockman (1991) notes:

> *Our reform efforts have dealt with practically every instructional issue one-at-a-time—and still we persist in our belief that schools are not performing as well as we would like and are in need of additional reform. (p. 24)*

Lorraine McDonnell (1990), in a Rand Corporation report, *Restructuring American Schools: The Promise and the Pitfalls*, observed that most educational innovations over the past 30 years

> *were designed to change educational practice only marginally, leaving the basic model untouched. The federal effort in supporting the achievement of the national education goals and the development of challenging content standards is part of a broader effort to create systemic reform in education and, in effect, to redesign the basic model.*

The federal government's effort to create systemic reform in education is being guided by a substantive conception of reform in curriculum that comprises two interrelated elements: (1) restructuring of the curriculum within schools and classrooms with the aim of achieving the national education goals and (2) systemic initiatives to build the capacity of schools to undertake restructuring of education. We believe that investing in technology, at the state and local levels for the purpose of achieving curricular goals would be the best possible approach for building capacity to undertake reform efforts.

Such whole-school transformation insists on the coordination and alignment of changes across all dimensions of schooling—higher-order learning outcomes for students, curricular alignment, collaborative instructional strategies, alternative assessment procedures, collegial professional environments, participatory management structures, and more meaningful school-community relationships. Systemic school reform will take time, and there is no magic bullet.

Implementing the new standards will mean defining roles for teachers and students that differ significantly from traditional practice in many cases. The new standards encourage the teacher to act as a facilitator in the classroom, guiding student learning rather than prescribing it. The students, in turn, "construct" their own knowledge, based on information and data that they manipulate themselves. No longer will they sit passively and memorize. Given this focus and the redefining of roles that it implies, we can see clearly why meeting the new challenging state and national content standards through the prevalent education structure and established practices in the current educational system will be difficult, if not impossible.

Implementing the new standards will mean defining roles for teachers and students that differ significantly from traditional practice in many cases.

Access to information and technically sophisticated knowledge tools are useful for particular applications, but they also have an impact on the very way we communicate, learn, and work. Yet, as our education system wrestles with the issues surrounding the restructuring of schools, many educators are ill-informed about how policies addressing the NII or evolving telecommunications technologies might assist them in addressing such issues. It is our belief that although the NII is promoted as a great equalizing force in education, it has the potential to exacerbate existing inequities.

Section Two

Increasing the type, the quality, and the number of professional development opportunities in the content areas and enhancing these opportunities by applying telecommunications and information technologies will make it easier for teachers to begin to experiment with new approaches to instruction. Without the opportunity for focused, sustained professional development addressing standards, research on learning, and strategies for change in the classroom, reform efforts on any level will be very difficult to achieve.

It is our belief that decisions about investing in technology for schools should be based on a clear set of expectations for the curriculum.

Technology emerges as a powerful tool to help implement systemic reform and enhance instruction in this new, more challenging learning environment. It can help teachers and their students successfully play the new roles that will be required of them. For teachers, it means being able to report and chart progress on a more individualized basis, even as the learning experiences themselves become more collaborative. Teachers can take advantage of resources that are available to them from across the globe or across the street and create different learning environments without ever leaving the classroom. In addition, professional development activities and courses will be accessible to them electronically. Students, on the other hand, will be able to access a vast array of material, consult with experts and peers through networking capabilities, and analyze real-world problems and questions. This process means using time in the classroom to concentrate on concepts rather than on discrete facts, suggesting that the idea of what a school is, as well as the structure of the school day and class periods, will be redefined.

Education policymakers at the state, district, and local levels need a basis for making decisions about investing in telecommunications systems and information technologies. It is our belief that decisions about investing in technology for schools should be based on a clear set of expectations for the curriculum. However, it is penny-wise and pound-foolish to invest in technology without investing in necessary ongoing professional development and training for applying the technologies to the curriculum.

We believe that investment in technology for schools at the federal, state, and local levels needs to follow a clearly stated set of standards of what the state, district, and schools expect children to know and be able to do. Once these curricular standards are agreed upon, investment in technology—especially from the school perspective—should begin with asking how telecommunications and information technologies help achieve these curricular expectations. Explicitly stating expectations for students and then designing a system using technology to meet these expectations will require systemic changes, meaning changes at every level of government influencing education. It is this systemic education reform effort that the Goals 2000: Educate America Act seeks to implement.

Federal Legislation, the NII, and Education

At the federal level, legislation is being developed in a number of different areas that would address the issues of equity, access, regulation, and planning as they relate to technology.[8] How best to invest in telecommunications and information technologies for schools and how much to invest are key issues that state and local educational agencies as well as the federal government will have the most difficulty addressing on their own given the financial constraints that face them already. Debate over the development of the NII, in particular, centers around issues of accessibility and affordability to anyone who wants to use it.

NII Legislation

The House legislation, H.R. 820, is called the National Competitiveness Act of 1994 and was introduced by Representative Valentine (D-N.C.). H.R. 1757, the National Information Infrastructure Act of 1993, introduced by Representative Boucher (D-Va.) in 1993, will become a part of H.R. 820. The Senate version, the Information Infrastructure and Technology Act of 1993 (Title VI of S. 4), was introduced by Senator Hollings (D-S.C.).

Title VI is largely based on legislation introduced by Vice-President Gore when he was a senator. The purpose is to

> *expand the scope of the National High-Performance Computing Program to identify and promote the development of applications of high-performance computing and high speed networking which will provide large economic and social benefits to the nation.*

The first application to education is mentioned in Section 603(a)(3)(A)(i) and states that the main purpose of this section is to "improve education at all levels, from preschool to adult education, including the development of new educational technologies."

Section 604, Applications for Education and Libraries, provides money to the National Science Foundation (NSF). However, Section 604(a)(5) requires that

> *the National Science Foundation and the Department of Education, in cooperation with other appropriate agencies, shall provide for the development of advanced computing and networking technology for use in education at all levels.*

Four hundred four million dollars has been authorized for this section, which includes the development of a digital library networking system.

In conjunction with other agencies, the Department of Education can develop and implement training programs for teachers, students, and librarians in the use of local and national computer networks.

Within this legislation, Section 206, Role of the Department of Education, explicitly authorizes the Secretary of Education to conduct basic and applied research in computational sciences in order to coordinate the efforts of libraries, school facilities, and educational research groups to develop, evaluate, and apply software capabilities in education. In conjunction with other agencies, the Department of Education can develop and implement training programs for teachers, students, and librarians in the use of local and national computer networks. Authorized to the Department of Education is $11.9 million for FY 94, $22.1 million for FY 95, and $23 million for FY 96. In addition, another $5 million has been authorized to the Department of Education to provide access to networks for school facilities.

Section 610, Support for Computer Education Program, calls for NASA to establish a Computer Technologies for K-12 Education Project to test and demonstrate educational applications of advanced computer technologies in public school systems that provide precollege education. Competitive grants will be awarded to plan, deploy, manage, and operate advanced educational applications of computer technologies in K-12 public school systems. Eight million dollars is authorized for each of FY 94 and FY 95.

Another part of the bill would require the director of the Office of Science and Technology Policy, through the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), to establish an Information Infrastructure Development Program.

As of late March 1994, the conferenced bill of H.R. 820 was waiting to be voted on by the full Senate and House. Title VI of S. 4 is now Title VI of H.R. 820. Sources in the Assistant Secretary's office suggest that the Administration's recently formed 24-member NII Advisory Council, which is made up mostly of representatives from industry, but does include one teacher, will be substituted for the Information Infrastructure Development Program when the bill is passed. The legislation would be amended to reflect the establishment of this Council and would fulfill the roles called for in the law.

Both H.R. 2728 and S.1040 recognize that the acquisition and use of technology in education throughout the United States has been inhibited by the absence of federal leadership.

One of the authorized activities called for in the conferenced version of the legislation has direct implications for education because it provides for the funding of pilot projects connecting primary and secondary schools to the National Research Education Network (NREN).

NREN is charged with developing high-speed networks and has a mandate to include K-12 schools in this development. However, up to now, very little funding or effort has been given to include K-12 schools in the development of the NREN. Another complicating factor for education policy and the NREN is that H.R. 1757 designates the NSF—not DoEd—as the lead agency for education and libraries. It does, however, authorize a Connections Program to connect all levels of educational institutions, libraries, museums, and state and local governments to one another and to the NREN and/or the Internet. However, if education does not assume a leadership role with respect to the NREN, NII, and K-12 schools, then the integration of telecommunications and information technologies into our elementary and secondary schools will continue to be disjointed and inequitable, further exacerbating existing inequities within our schools.

In addition, specific bills relate to educational technology in particular, and these bills will be discussed next because they set the framework for policies that will affect planning directly, which is the first major consideration for any investment in educational technologies.

Technology Initiatives

Congressman Sawyer (D-Ohio) introduced H.R. 2728, the Technology Education Assistance Act of 1993, and Senators Bingaman (D-N.M.), Kennedy (D-Mass.), and Cochran (R-Miss.) introduced S. 1040, the Technology for Education Act of 1994. Both initiatives assume that it is essential to establish a comprehensive, systemwide, appropriate educational technology infrastructure to enhance curriculum, instruction, and administrative support services if there is any hope of achieving higher education standards and the national education goals.

Both bills recognize that the acquisition and use of technology in education throughout the United States has been inhibited by the absence of federal leadership. As a result, each calls for the creation of an Office of Educational Technology placed within the Department of Education in order to develop and sustain federal leadership in this area.

The importance of these efforts is reflected in the incorporation of H.R. 2728 into H.R. 6, the Elementary and Secondary Education Act (ESEA), Subpart 2—Research, Development, and Demonstration of Educational Technology, and the section of Title II in Goals 2000 that addresses planning for educational technology. Both of these sections concentrate on issues of funding assistance and integrating technology with national goals and standards.

States recognize the importance of establishing some decision-making authority at the state level to support and encourage the use of technology throughout the educational system.

Each bill also requires the Secretary of Education to develop a national long-range plan to address how technology will be made an integral part of education.[9] The contents of the plan must include information about everything from how the Secretary will encourage the use of technology in helping students meet new high standards and joint activities with other federal agencies to how technology will be applied to efforts aimed at state systemic reform and professional development for teachers.

Some states have implemented technology programs of this kind. Their programs are examples of the importance of establishing some decision-making authority at the state level to support and encourage the use of technology throughout the educational system.[10]

Horowitz (1993) also provides some models of states that

> *. . . already promote the systemic use of technology. . . . Texas, for example, has created a statewide process for selecting and using interactive videodiscs in its public schools. Kentucky is establishing a set of technical standards for personal computers to be used in its schools and is setting up a state contract to permit individual school districts to purchase computers at quantity discount prices. Massachusetts has a quasi-autonomous public corporation to provide and foster the use of telecommunications-based education services and materials throughout the state. (p. 36)*

Summary of Federal Policy Issues

Movement is occurring in both national and federal arenas to create the infrastructure that will support the use of technology in education. Like any other policy issue in education, and as this paper makes clear, researchers, policymakers at the state, district, and local levels, and educators must work together to address concerns from formulation through implementation. Each group has a particular role to play.

Federal policymakers can create conditions that promote educational applications for technology. Activities such as the development of the NII, technology initiatives that include education components, legislation such as Goals 2000: Educate America Act, the establishment of the National Education Goals, the development of national content standards by various national education organizations, and university support for teacher training in technology are all part of the foundation that will make it possible for individual teachers to concentrate on making technology an integral part of their instruction. We do not believe that we will be able to restructure education to meet the new national goals and to meet the higher content standards for all students unless educators apply and integrate appropriate technologies in their daily routine. Teachers will have to become models of lifelong learning or inquiry-based learning over a lifetime. They will have to apply, use, and become expert in adapting technology to meet curricular needs. In other words, formulation cannot be divorced from implementation, although it is true that, taken together, these two tasks reveal the complexity involved in the whole process. As Milbrey Wallin McLaughlin (1987) points out:

> *The problem for analysts comprises linking the nominalistic world of the street level bureaucrat to the systemic patterns that comprise the world of policy makers—combined intentionality or collective action and predictable institutional effects. The quality of individual-level responses determines the quality of policy implementation; the nature and level of changes evident in the organization or in the aggregate status of target groups determine the extent to which policy has addressed macro-level problems. (p. 177)*

As we shall see, related activities at the state and local levels also contribute to this process. The extent to which federal policy facilitates local policy and vice versa, as well as how well both meet the needs of educators, will mean the difference between simply adding technology on to existing programs or integrating it into the entire system.

Many state technology policies and plans reflect a demand for information about student learning outcomes and the cost and benefits of education programs.

State-Level Policies and Education Technology

In states with technology plans, there is a common belief that technology has the power to increase the effectiveness and efficiency of the learning environment of the classroom. In the case of the seven states in the North Central region (Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin), broad statements in the state technology plans refer to technology as a critical element in educating students for life in the 21st century. The idea that technology is an extraordinary vehicle for achieving restructuring and improvement in student learning frequently appears.

Generally, in these documents, the states are asked to take the lead in:

- Developing a plan for integrating technology throughout the curriculum and assuming that:
    - Technology is an intellectual tool, useful for creating, exploring, interpreting, generalizing, constructing, and reasoning
    - The appropriate use of technology can improve both what is taught and learned and how it is taught and learned
    - Access to a wide variety of technologies must be possible for all students and teachers
- Specifying the technological resources that should be available to all students, classrooms, schools, and districts
- Identifying the professional development that will be necessary in order to integrate the technology
- Assuming responsibility for management, accountability, and operation of the system, allowing for:
    - A flexible system of reporting that can meet local, state, and national accountability requirements
    - A management information system that is integrated and flexible enough to provide necessary information relevant to policy considerations over time
- Developing appropriate instructional goals, objectives, and strategies

Many of these state technology policies and plans reflect a demand for information about student learning outcomes and the cost and benefits of education programs. With such information at hand, the assumption is that accountability and decision-making will be made easier and more cost-efficient.

Technology is seen as having the unique potential to help create real, sustained reform in education. It is considered a means for restructuring the learning process and more effectively meeting student needs in a global/information society. According to state planners in the North Central region, integrating technology into the education system through telecommunications and electronic networks will transform education at the building, district, area, and state levels to support the learning process.

Creating the Perfect Fit

The integration of technology into the curriculum as a tool to help drive school restructuring and systemic reform in education should concentrate on matching technologies to the needs and financial resources of the state, district, or school. Some states, districts, and schools have invested heavily in technology; the majority of states, districts, and schools are beginning to make decisions about investing in telecommunications and information technologies.

We advocate a policy of developing specific high-achievement expectations for all students in all schools and districts. The next step is to develop curriculum frameworks that are consistent with these expectations of higher standards. Then it is the responsibility of the states to provide technical assistance to schools and districts to help them choose appropriate technologies and/or adapt existing technologies that will help the schools and districts meet these new high standards for all students.

One of the questions that will have to be considered and perhaps only answered through trial-and-error is how the technology can be most effectively introduced. As we have seen, Goals 2000: Educate America Act and the Elementary and Secondary Education Act are focusing their attention on the acquisition of higher-order thinking skills by all students. They suggest a movement away from basic skills and a developing recognition that higher-order thinking skills can and should be taught alongside basic skills. Although learning often does require a student to understand certain concepts and principles in order to learn new skills, the result in schools has been that basic skills have been taught as discrete units unto themselves. Disadvantaged students, in particular, suffer under these conditions, because the curriculum rarely moves them into instructional programs that feature higher-order thinking skills.

One of the questions that will have to be considered and perhaps only answered through trial-and-error is how the technology can be most effectively introduced.

By implication, then, when trying to implement technology, we should expose teachers to hardware and software that provides for the application of a wide range of skills. As Table 1 illustrated, we want to promote technologies that are properly matched to the tasks for which they will be used. Sometimes it will be appropriate to use technology for drill and practice; other assignments will require that the technology be able to link students and teachers to a wide range of human and information resources.

We are not advocating throwing out the baby with the bath water. Existing telecommunications and information technologies within schools and districts should be adapted and upgraded to continue to meet the role for which they were initially intended. As Herman (1993) notes:

> *Well-controlled studies comparing students taught with CAI and those taught conventionally, in fact, have consistently favored CAI at the elementary, secondary, and post-secondary levels (Kulik, C.L., & Kulik, J., 1991; Kulik, J., Kulik, C.L., & Bangert-Drowns, 1985). (p. 110)*

We are advocating multiple technologies to meet different needs at multiple sites within the classroom, the school, and the district. Schools ought to be able to use their older computers for simpler tasks like keyboarding, spelling, basic knowledge development and reinforcement, and educational games, as well as other curricular skills development activities.

What we know about how individuals learn is only beginning to be articulated; our understanding of how individuals learn to use and apply technology is even less well-developed. As a result, it is difficult to decide whether to advocate for low-end or high-end technology as a starting point. The best bet, we believe, is to continue to try to make appropriate matches between technologies and tasks.

Building Interactivity

It is important to emphasize the changes that must occur in the entire system in order to accommodate the changes implied by the introduction and integration of technology. Changes in the structure itself, such as the length of the school year, can go a long way toward creating the most appropriate environment. As Michael J. Barrett points out in the November 1990 issue of *The Atlantic Monthly*:

> *A longer school year, while hardly sufficient in itself to reclaim quality in American education, is a superstructure under which other changes can be made. A school year of, say, 220 days will serve as a big tent. A number of things may go into the tent to make it a better place; to accommodate them all and to arrange them in proper order requires the space the tent provides. (p.100)*

There will always be a transition time during which new learning will have to be integrated into the schedule of the end-users. This period must be planned for and budgeted.

It is also important to find the proper fit for technology so that the end-user gains comfort and becomes expert as he or she integrates technology into the daily routine. Technology cannot simply be provided with the assumption that its uses will be apparent and that the users will know what to do with it. There will always be a transition time during which new learning will have to be integrated into the schedule of the end-users. This period must be planned for and budgeted.

With teachers as with children—indeed, with any human being who learns a new strategy focusing on problem solving and active learning—we believe that it is necessary to provide opportunities for interactive activities. But this approach to learning takes time. For instance, in an approved but unfunded proposal to the National Science Foundation submitted by Robert N. Beck as principal investigator from the University of Chicago/-Argonne National Laboratory Center for Imaging Science, students in grades K-12 were to learn about the brain through interactive modalities depending upon their age and level of expertise. Prior to describing the modalities or versions recommended for specific age groups, the proposal lays the groundwork for the reasoning behind these decisions:

> *Most would agree that human vision provides our principal means for knowing ourselves and the world around us, and that language provides our principal means for communicating what we know to others. It is important to recognize that these means for knowing (through visual images) and for communicating (through words) have been separated in the past. In part, this separation is due to the fact that it is much easier to record and to reproduce words than images. Every technological advance that has enabled us to bring together images and words, that is, to cause them to converge within a single medium, has had a major impact on our culture and on education. As examples, printing, motion pictures, and television have had an enormous impact on education. However such media communicate visual and verbal information and knowledge to an audience that is essentially passive; hence the difficulty of sustaining audience attention without resorting to the presentation of emotionally charged materials. This is particularly true of*

> *motion pictures and television, where the reader/viewer/listener not only has no control over the content of the presentation (beyond its selection), but also has no control over the rate or the sequence of its presentation. In large part, this may account for the popular appeal of video tape technology, which is now widely used for both entertainment and education. This technology incorporates features such as fast-forward, slow-motion, freeze-frame, and re-wind that enable the viewer to be somewhat more selective of the content, rate, and sequence of presentation. These interactive features tend to sustain attention, which is well recognized as an important factor in learning. . . . (Beck et al., 1991, p. 2)*

Beck goes on to describe the design of each version and how the versions become gradually more interactive. They are useful in part because they are based on videotape technology; the first two versions, in particular, can be widely distributed and the equipment that classrooms will need to apply them to classroom activities is relatively inexpensive and easy to use. The versions have the following characteristics:

- Version I (for elementary schools) will consist of a videotape of approximately one hour's duration, suitable for very broad distribution. It will explain (with visual and verbal materials) how the different parts of the human brain are involved in normal sensation/perception—touch, smell, taste, hearing, and vision—as well as in the production of speech and motor activities.

- Version II (for junior high schools) will consist of a laser disk containing several hours of visual and verbal material (including Version I) that will provide an introduction to topics concerning the brain . . . . These materials will be accessible randomly; thus, this version will be suitable for teachers to use in leading classroom discussions that follow the interests and concerns of the students.

- Version III (for high schools and museums of science and technology) may consist of one or more laser disks (or, more likely, information contained in mass storage that is randomly accessible to multiple workstations simultaneously via a high-speed network). This version will be designed for interactive, exploratory use by students and will include not only the information contained in Versions I and II, but also information about how researchers and scientists study the brain. (Beck et al., 1991), p. 1)

Version III will would make it possible to

> *[vary the] mixture, as well as the rate and sequence of presentation, in order to maintain a high level of interest and motivation to learn. (Beck et al., 1991, p. 3)*

The use of videotape technology for younger students is modeled as the teacher controls the presentation of information on the videotape.

At each stage, therefore, the technology becomes increasingly more interactive. This interactivity builds off of the capabilities of the particular age and grade level of the student, permitting older students to control their learning according to their abilities and needs, while the use of technology for younger students is modeled as the teacher controls the presentation of information on the videotape.

A key aspect of this proposal is that it presents material to students about an unfamiliar topic through interactive, technology-based instruction that is incremental, taking advantage of different technologies. As students become better able to guide their own learning, increasingly interactive means must be available to them, not only to enhance their learning, but also to hold their interest.

We do not advocate for this one approach. Rather, we offer it as an example, in addition to the other approaches such as the Jasper Series, IPT, and CoVis, described earlier—approaches that apply multiple technologies to multiple environments for which they are best suited.

Where Are We Going and How Do We Get There?

Implementing any technology requires us to ask ourselves the broader question of what it is we want out of our education system. The impetus from the federal government for states and local districts is for systemic reform. What is it we want kids to come out being able to do? Do we want them to be thinkers? Do we want them to be able to make an argument and defend it? Do we want them to be able to plan and carry out a scientific experiment? Whatever question or questions it is we ask, as we consider answering it through the implementation of technology, we must determine what a given technology can do and whether it will bring us closer to our learning goals.

We must determine what a given technology can do and whether it will bring us closer to our learning goals.

As Jane L. David (1993) notes:

> *For technology to be used as a powerful learning tool and as a support for reform, certain local conditions must be in place. Whether the use is for administrative, managerial, or instructional purposes, the technology must be readily accessible and functionally suited to the task; and the user must have the necessary training, knowledge, and technical support to use the technology appropriately.*
>
> *Access to technology requires that technology be readily at hand for use as needed, not simply for uses that can be predicted in advance and squeezed into a fixed time slot. For example, teachers are far more likely to use video for instruction when the choice and timing are under their control. Similarly, teachers and administrators are less likely to use telecommunications networks when they must go to a remote location to do so. Nor can students exploit the power of word processing if they must wait for their daily or weekly scheduled time in a lab. The technology must be readily accessible for use when it is needed. (David, 1993, pp. 7-8)*

What is clear is that technology in and of itself must be planned and managed. We have argued above that technology is essential for fully realizing the national education goals and the new state curriculum frameworks. The new telecommunications and information technologies will be able to support individualized as well as collaborative learning and extend learning beyond the classroom and the schools, supporting a variety of strategies for achieving curricular goals of individual schools, districts, and states for all students.

Telecommunications and information technologies can more efficiently and cost-effectively accomplish the goals of inquiry-based learning. Stressing interactive rather than passive learning, situated learning, where the teachers and the learner have shared experiences, makes possible the active development of mental models for problem solving. Using technology for specific learning goals will give all students opportunities to solve relevant, real-life problems or tasks within each discipline by accessing primary data sets such as photographs taken by the Hubbell telescope or historical texts through the Library of Congress or other libraries that may make their material available online. This type of access beyond the classroom is possible through simple technology using a computer and a modem. These technologies will allow students and teachers access to other classrooms across the country or the world, as well as the chance to "talk" with scientists and researchers. Without telecommunications and other information technologies, this kind of information access and manipulation of primary data would be prohibitively expensive or impossible to accomplish for schools.

Some classrooms already have the ability as well as the opportunities to access this kind of information; however, most elementary and secondary students do not. Appropriate state and federal policies will guarantee access to all students and provide support for this type of learning through the use of information technologies.

Teachers Must Feel Comfortable

Teachers should not spend an inordinate amount of time learning to use technology or maintaining the system. Teachers should and must continue to devote their time to teaching. Students should and must be able to engage in inquiry-based learning, actively involved in and creating their own knowledge. In order to accomplish these goals, it becomes clear that there is a need for a management and maintenance plan as well as a plan for ongoing professional development in the integration of these technologies into the curriculum.

The technology should not cause so much difficulty that teachers just go back to doing what they were doing in the first place.

The technology should not cause so much trouble that it interferes with the daily routine, nor should it cause so much difficulty that teachers just go back to doing what they were doing in the first place. Teachers will have to see how technology can help them do their job better, which will take time; therefore, starting slowly and planning for training in the use of the technology, in learning theory, and in the new higher content standards is a must.

Categories of Use

The best rule of thumb is to choose technologies whose applications to curriculum goals are clear and to create support mechanisms for their use. Our criterion is whether the technology is useful for reaching explicit student learning goals. Two specific categories of use should be considered at any level before investing in telecommunications and information technologies for schools. As decisions are made, it is important to keep in mind which category is being affected, so that scarce resources will not be spent unwisely.

Category One is devoted mainly to familiarizing teachers, students, and administrators with the technology itself. It introduces the various technologies and shows what these technologies can do for different purposes, such as creating and using databases or spread sheets, word processing, and managing information. Category one is concerned with using technology to do an existing job or task better or more efficiently, such as searching an encyclopedia from a CD-ROM disk, connecting to and browsing through databases, or designing a curriculum unit or even an entire curriculum. Teachers with little background knowledge in applying telecommunications and information technologies in the classroom for both administrative and academic tasks should be allowed to explore the potential uses of the technologies.

Category Two involves using the technology in creative ways and emphasizes the construction of knowledge. It requires a lot more work and time in training the teacher, student, or administrator and generally requires more sophisticated technology. The implication is that the structure of the school system and the school day are configured so that they support the use of technology in these ways. It means that resources—personnel, hardware, and software—must be available and accessible. Unless this sort of infrastructure is created, the system will reject the new application, because the application will not be in keeping with existing practices.

Systemic Benefits

As schools, states, and districts invest in technology, they will also need to convince school boards and the public that investing in technology will, in fact, enhance teaching and enable students to learn more effectively. We argue that they will succeed only if the investment in technology is based on achieving curricular ends. Herman (1993) stresses:

> *Technology cannot effortlessly transform education. Productive reform will require sustained attention to curricular and instructional change, to technology solidly grounded in effective action theories. Just as technology must be built on significant and meaningful curriculum, so efforts to*

> *integrate technology into schools must be combined with professional development in effective curriculum and instruction. Transforming education will require that we get smarter about how best to use technology to support effective instruction . . . (Herman, 1993, p. 132.)*

More important, school boards will have to understand that the appropriate application of telecommunications and information technologies can be an important tool for reducing resource inequities between schools and districts—with the help of deliberate and careful choices and a little determination. As referenced in Mageau (1992), even the principal of a poor school in Rocky Ford, Colorado, Liberty Elementary,

> *with the money available to him . . . [was able to] install one 25-station lab of Apple IIGS computers running Classworks (an ILS from Computer Networking Specialists) over a Digicard network. The lab has a liquid crystal display (LCD) panel, so that teachers can use the ILS for whole-group as well as individualized instruction. Additionally, there is a "mini" distributed network in the school: Every classroom has one computer hooked up to the central file server, from which students and teachers can access the system. (p. 17)*

Such systems encourage teachers to take a critical look at their instruction and investigate ways in which they can individualize instruction and monitor students' progress—often resulting in an improvement in achievement levels.

School boards at the state and local levels will have to address the issue of planning for technology so that the technology becomes accessible to all students and is functionally appropriate. The technologies that are adopted need to be in places that can be easily accessed when needed by either the student or the teacher, and the systems need to serve the learning purposes for which they were designed. In addition, David (1993) emphasizes that

> *[t]eachers as technology users also need technical support for operating hardware and software and diagnosing maladies. Like professional support, technical troubleshooting and assistance need to be readily available. When malfunctions occur in the middle of a lesson, leaving the room to telephone someone in another building is not feasible. This problem is likely to diminish over time as more and more students become technically proficient and as teachers become more comfortable turning to students as sources of expertise (Ringstaff et al., 1992). (David, 1993, p. 9)*

The technologies that are adopted need to be in places that can be easily accessed when needed by either the student or the teacher.

School boards must be made to understand that telecommunications and technology applications can serve systemic needs, addressing not only instructional purposes, but also staff development, administrative, managerial, accountability, and equity purposes. We must make sure that these technologies are serving the needs of students and teachers through appropriate planning at all levels of the education system. One way is to develop guidelines or principles for purchasing of technologies. One such example of a set of guiding principles comes from Kentucky:[11]

> *Kentucky's Master Plan for Education Technology (Kentucky Department of Education, April 1992) is built around a set of design principles called "strategic decisions." These principles express the goals for Kentucky's technology system without unduly constraining choices about technologies.*
>
> *The principles embody the vision of a coordinated statewide system that includes both instructional and administrative uses. The system is intended to be flexible and to expand incrementally by building on distributed networks of small computers. It is designed to have open system standards*

> *that will support a variety of vendor hardware and software.*
>
> *Another principle is that of connectivity—networking student workstations, teacher workstations, and student and school management systems, as well as district and state administrative systems. In addition to integrated major applications, the intent is to develop a common user interface throughout the system.*
>
> *Finally, the system is designed to be highly accessible to students, staff, and parents, and highly protected in ways that ensure security without limiting access. Ideally, decisions should be driven by what will be, not by what is—and by how technology can contribute to this transformation. Thus, for example, decisions about networks need to consider the information needs of moving toward and supporting a more decentralized system. (David, 1993, p. 11)*

Clearly, these "strategic decisions" are the very same issues we have been addressing separately in this paper. There have to be guiding policies that allow telecommunications and information technology policies to be consistent. Without these principles to guide the development of the NII, the public good will never be addressed. Since the federal and state governments have regulatory power, as servants of the people they need to ensure that these services can be used by all, including a very important segment of our population—i.e., the 45 million K-12 students and 2.5 million teachers, and the millions of support staff and other secondary agencies that rely on education to perform their jobs.[12]

While we may identify trends, we cannot point to one right answer to the question of what to invest in for educational technology. In using any state network backbone, what states can afford and their expectations for use will and should vary. But states, in their planning, need to consider how they will connect with the NII and other states and resources and what types of changes in state telecommunications regulations will support federal regulations in telecommunications policy that guarantee access for all students. Using guiding principles or standards provides a way to plan an articulated system that anticipates connectivity and equitable access, as well as local, state, and national uses and appropriate funding.

States need to consider what types of changes in state telecommunications regulations will support federal regulations in telecommunications policy that guarantee access for all students.

The State of Ohio recognized the importance of access and tried to address the issue through the provision of Technology Equity Grants. These grants are a line item in the state budget and provide $5 million annually. The grants are made to school districts or consortia of school districts and are targeted to the poorest one-third of the districts in the state. The grants are used for developing programming through the broadcast network according to the needs of the district.

One of the goals of the program is to make it possible for schools and districts to continue programs that have been introduced or piloted by the telephone and cable companies. Once funding from these sources is removed, the schools and districts often find themselves unable to continue the program, even though the equipment has already been purchased and is in place. In these cases, it was the private sector that made access possible, but it is the public sector, through funding provided by the state, that will ensure the continuity of that access. Making money available for these purposes through the Technology Equity Grants has made it possible to sustain the technology.

Planning for Connectivity

Connectivity is one of the major issues that states need to consider when planning for technology. It is private industry that will create the state backbone or information highway that will connect to the NII. But it is the state, through regulatory agencies, that will decide where schools will be able to enter and leave this highway. For example, Iowa created a fiber-optic backbone, Nebraska created a backbone connecting ESUs, and Texas created an Internet backbone.

Planning for connectivity also will require states to determine whether they will invest in wire technology or wireless technology, or a combination of the two. In order to answer this question, they will have to determine the flow of expected traffic over the network and whether the network will serve only education or other social agencies as well.

In our opinion, it would be much more cost-effective to develop a network to handle the traffic of several social service agencies related to the needs of students. Creating a network that allows for the development of an integrated services model of social services or, at least, student and child services, would make it possible to disperse the cost of the network and the on-line fees over a wider number of subscribers. This type of planning will provide for the creation of integrated services systems for students and their families that are otherwise cost-prohibitive.

States must determine how much they will or can pay to subsidize resource-poor schools or districts so that an equitable balance is achieved and access to the network is ensured for all clasrooms.

A related question is how much it will cost to add additional bandwidth or lanes later as the need for services grows and the capacity of the network has to be increased. States will have to determine what the school districts and/or schools will or can afford to pay initially. Then they must determine how much the state will or can pay to subsidize resource-poor schools or districts so that an equitable balance is achieved and access to the network is ensured for all classrooms. It would be absurd for state policy to exacerbate the gap between the technology "haves" and the technology "have nots" in their own states.[13]

Thus, resources will have to be allocated to guarantee connectivity within the school. Multi-year plans are necessary that have a built-in capability to change over time. The most costly investment that is least likely to change over time is wiring, which becomes the main controller of capacity of the network.

Burns, Zachmann, and Swartz (1992) encourage connecting students, starting at the high school level, with the resources and capabilities of networking. Even then they find that such a task can be a complicated endeavor, depending on the complexity of the system and the extent to which teachers will need training prior to using networking in the classroom. Building off of this experience, they propose alternative models that are less challenging, yet will enable schools to take full advantage of all that networking has to offer:

> *Our intent is to recommend technology that will provide: (1) a robust connection to the Internet, (2) the capability to perform visualizations on local workstations, and (3) an environment that will facilitate management by the regional Network Operations Center (NOC). (p. 7)*
>
> *[While] [t]here are several technologies for connecting computers to Local Area Networks, (they) recommend the use of Ethernet for Local Area Networks for three reasons: (1) it is inexpensive, (2) it is fairly straightforward to manage, and (3) it is sufficiently fast to enable good transmission (it is rated at 10 Mbps, but typically only 2 to 3 Mbps is realized). (p. 9)*

Expanding on these ideas, David R. Hughes (1994), in a paper entitled *Appropriate and Distributed Networks: A Model for K-12 Educational Telecommunications*, states as follows:

> *There is a strategic need to gradually, and progressively, educate and acclimatize public school decision makers, including the local parents, tax-paying public, and press, to the comparative cost-benefit value of distance learning. In addition, there is the need for giving teachers and administrators a chance to learn progressively themselves how to use, and then effectively teach others with technological networking tools. (p. 4)*

Hughes makes a strong argument for low-cost, low-tech solutions, because a lot of unused (for a long time) hardware, software, and networking capabilities is being paid for—which can well be rendered obsolete by the time its full potential is realized. He stands in marked contrast to those who believe that the only acceptable rock-bottom aim is to have every school on the Internet at the telnet/ftp level from the outset. He estimates that the costs for developing this kind of connectivity for all schools in the United States stands between $500 million and $1.2 billion.

Once again, we must stress that adopting and adapting the various levels of connectivity must be based on the levels of use, the cost, whether education will be the only user, and whether the system will allow for integration of different agency services that include education.

Planning for Maintenance: Another Critical Issue

One key hidden variable in any electronic networking system or telecommunications application for education is maintenance costs for the life expectancy of the system. For example, when buying a car, it is not generally the case that one asks which is the best or the ideal car without first considering such questions as what can one afford, what will the car be used for, how fuel efficient is the car, how reliable is the car, and how much maintenance and upkeep will cost. If one chooses to buy an expensive car, it is fairly certain that the maintenance and use costs will be more expensive than they would be on a less expensive model. The same kind of logic should be applied to investing in a network system, whether it be a "backbone" at the state level or a Local Area Network (LAN) at the school level.

One key hidden variable in any electronic networking system or telecommunications application for education is maintenance costs for the life expectancy of the system

As the states plan for technology investment, they need to consider what we choose to call "hidden costs," because these costs are rarely discussed or planned for when investing in technology, but rapidly become the major cost issues once initial planning or project monies have disappeared. These questions include the following:

- Who will maintain the system?
- Who will manage the server?
- How will the leasing arrangements be managed?
- Who is responsible for the day-to-day operation of the system?
- Who will be responsible for introducing content?
- Who will be responsible for evaluating the system's use and effectiveness?

To help think of these issues, let's use another analogy, this time of trucks that run along the highway system. The highway is owned, maintained, and supported by different entities, but truck companies do not need to be aware of these entities and how they operate on a daily basis—they need only know to whom they must pay user fees and taxes. Similarly, trucks are owned and operated by different companies for different purposes. The highway system is built so that a variety of types of trucks can use it for different legal purposes, and they pay for that use accordingly.

Now, think of the state agencies owning, maintaining, and operating the state backbone network, and then think of the schools and districts as independently owned and operated entities using and paying to use this information highway. In an information highway, we will have to consider who will pay for the development of the system and who will ensure open access and affordability. It may be the case that different entities take or are given responsibility for these different aspects.

In an information highway, we will have to consider who will pay for the development of the system and who will ensure open access and affordability

But if these management, operation, and maintenance issues are not planned for and budgeted up front, then the central question in sustaining the use of the technology will become financial—not whether it is serving the state's education goals and needs.

Planning for Technical Standards

We believe that state technical standards must be developed for instructional software.[14] These standards should not be related to content but to issues such as the following:

- Ensuring that the software could be used on any type of hardware available in schools
- Providing the option of integrating video and audio recording with text and computer graphics
- Creating user interface standards so that teachers and students will not be expected to learn new strategies for new software
- Developing database interface standards so that students and teachers can integrate national databases into their work.

Implementing these standards would then allow the software producers to develop programs for the entire educational market, assuming that states adopted these standards. If a region adopted these standards, it would create a market to which software producers could sell, rather than developing, individual systems for individual districts.

States also will need to choose communication protocols or technical standards. Generally, the accepted protocol is rapidly becoming TCPIP, which is the transport protocol for the Internet. Many proprietary networks are making it difficult to use the Internet easily. Regarding education, the state ought to be concerned with ease-of-access for teachers, because teachers ought not to have to spend a lot of their valuable time gaining access when they should and could be teaching. These same end-users need to be at the forefront when investment decisions are made. Will such a network be just for education, or will it be for a variety of users with their own needs? There will be different organizational structures depending on the configuration of schools within a district and the need for different types of access. Simple Internet access may be all that some schools can afford or will want to work with at first. Other schools may determine that their focus on constructivist learning would be better served by using Mosaic. However, certain implications accompany any given choice, such as whether or not the system can handle heavy use of the network—for example, when Mosaic is used with a graphics capability. Given these conditions, it is always wise to look at what other states have done and why they chose certain backbones over others.

Planning and Financing of Technology

Financing for educational technology systems poses problems because there is very little funding to be tapped at any level—local, state, regional, or federal. Local education agencies are limited in their resources, and state budgets are being tightened.

These issues were raised during two focus group sessions, one held at the North Central Regional Educational Laboratory (NCREL) in October 1992 and one held at the Far West

Laboratory in December 1992. Both were convened at the request of Senator Jeff Bingaman (D-N.M.) to discuss a draft piece of legislation entitled the School Funding for Technology Act. The groups included representatives from business, industry, higher education, and government and their charge during the sessions was to review the language in the bill and offer suggestions about how the legislation should attempt to address funding options and other policies concerning the integration of technology into K-12 schools. They identified the following conditions facing policy makers and administrators in this area:

1. States and regions often do not have plans that include procedures for funding technology.
2. Technology funding often is not a priority for teachers and administrators.
3. The cost-benefits of technology are often questioned.
4. Financial support for technology from business and industry is often inconsistent or not linked to education plans and needs.
5. Existing school and program funding for technology often is not targeted.

Financing is probably the biggest stumbling block for individual states in implementing educational technologies.

Financing is probably the biggest stumbling block for individual states in implementing educational technologies. The costs can be high, especially those associated with start-up. Cost is also an important issue when the state's goals include a statewide program providing for access to all students and interactivity. In putting together funds for such endeavors, states have taken one of two approaches: relying on monies available through outside sources or giving the responsibility of system development to local entities. The latter approach poses problems, however, because local agencies often find it difficult to access adequate funding, and there is no guarantee, without state standards to follow, that interconnectivity would be possible between locally developed systems.

Financing of telecommunications systems must be adequate for explicitly stated goals. It becomes apparent in reviewing the status of technology plans in each of the seven states in the North Central region that each state has taken a different approach to locating and distributing funds; yet, many questions remain unanswered for states around the issue of funding for educational technologies. In many cases, at the local, state, or federal level, standards that could guide choices about telecommunications systems and associated costs are nonexistent. Exacerbating the situation is the fact that fewer and fewer funds are available as budgets become tighter at every governmental level. The best bet for states under these circumstances is to investigate needs thoroughly and plan carefully so that any investment in a telecommunications system is able to accommodate changing conditions and increasing demands over time. One way to address the issue of insufficient resources would be to pool funds by means of a large consortium such as a region or by creating public/private ventures that could pay for designing and implementing these systems in schools. Both of these concepts will be discussed in a later section.

Summary of State Policy Issues

The main theme for planning for technology is to anticipate needs but to avoid doing everything all at once. Instead, a step-by-step approach is encouraged. The intention should not be to create a state-of-the-art technology system in education, because education is not the place to pay for creating or building this seamless technology. Educators at all levels need to work with the industry and the technology experts. The technologists should not be doing the educator's job, nor should the educator try to do the technologist's, but each needs to inform the other. Educators need to define their needs clearly , and then technologists will suggest a number of alternative systems that would fit those needs. Teachers then need to inform the technologists how well those needs were met. There is no one best technology system, and there are different magnitudes of consideration that different states will need to address. This conclusion is similar to the recommendation made about assessment in the document Surveying the Landscape. The term *technology* could easily be substituted for *assessment* in the following quote from that publication:

> ***There is no single best model for state assessment; innovation in the states should be supported and encouraged.*** *States have different goals for their assessment programs, and different approaches are necessary to meet those goals. The federal government should not impose a single model, but should support the innovation that is taking place and should encourage the states to network and share ideas. States need help and support from research and development in the area of innovative assessment; they do not need a new national agenda that does not take their needs into account (Bond, 1994, pp. 33-34).*

Implementing technology demands thinking of the education system systemically. Although curriculum—and beliefs about what students should know and be able to do—should drive any decisions regarding technology, it will also be necessary to take into account issues such as (1) the amount and extent of connectivity that is desired; (2) the cost of the system, including maintenance and sustainability over time; and (3) how professional development to support the implementation of the technology will be provided. Not only are all of these issues ones that must be considered in any decisions that are made, but they are also interrelated.

Connectivity is directly related to curriculum. Although the curriculum can be modified, what one wants to accomplish in this area in terms of the amount and extent of access to outside resources via telecommunications and information technologies will determine the type of connectivity required. Then, of course, different systems will have differential costs, with more complicated systems costing more than less complicated ones. Finally, the complexity of the system chosen also impacts how extensive the professional development will need to be. Looking at the implementation of technology in this way makes apparent the systemic nature of the process. Therefore, the more these issues are addressed systemically, the greater the likelihood that technology will be successfully implemented and integrated.

Educators need to define their needs clearly , and then technologists will suggest a number of alternative systems that would fit those needs. Teachers then need to inform the technologists how well those needs were met.

All in all, there are some general observations that can be made about the status of educational technology planning in states and the amount and type of assistance they require to build a solid foundation in this area:

- States and local education agencies are engaged in many technology development activities in education, but the picture does not provide a clear focus or direction for where to thoughtfully take us into the future. That will require further planning.

- There is much to be done to help those at the school level utilize technology to change the teaching and learning process. We do not see much of that reflected in planning for investing in telecommunications and information technologies.

- Education cannot be all things to all people. We will have to make some hard decisions about whether we place an emphasis on getting technology to schools, helping schools use technology, or developing technology products. Which of these roles should linking technology and school reform emphasize? Our belief is that state and local agencies should emphasize helping schools use technology to promote school achievement for all students.

- There is much to be learned about the process of effectively integrating technology into curriculum, instruction, learning, and teaching.

District/Local School Issues

K-12 Connections to the Internet: Low Tech or High Tech?

The main consideration for a district or school when choosing to invest in technology should be how the technology will get used. When a school is just beginning to invest in technology it should be introduced as an aid to the teacher, student, or administrator, making it possible to do the job that has to be done better. Most teachers will first need time to become familiar with low-level technology prior to transitioning to more sophisticated technology, mainly because it will be all schools can afford at first. They will need to establish a "comfort level" so that technology becomes a part of their daily lessons. They can then begin to integrate technology into their curriculum, accessing data bases, and so forth. Teachers need to see the utility of information technologies; otherwise they will not take the time to learn how to use them effectively.

Teachers need to feel that they can apply and adapt these technologies to meet their need.

Teachers need to feel comfortable in using the technologies. This comfort level can be brought about through sustained training, experimentation, and technical support supplied by the district or state. Teachers need to feel that they can apply and adapt these technologies to meet their needs. The approach used in the implementation of a networked integrated learning system (ILS) laboratory by James Wilkins, principal at Liberty Elementary School, a poor school in Rocky Ford, Colorado, illustrates this point. As described by a teacher on his staff (Mageau, 1992, p. 18),

> *Wilkins asked teachers to target one particular curriculum area, look at what the ILS offered by way of lessons and skills practice in that area, and bring their students in for one session. "Teachers immediately discovered the connection between the ILS and their outcome-based goals."*

The emphasis of use here is consistent with the change and reform literature (Berman & McLaughlin, 1977). This literature documents that change works best when teachers are involved in making decisions and in facilitating sharing new ideas with other teachers. For instance, in the case of a distributed network,

> *. . . [although] there is no one blueprint for managing an ILS in a classroom, [and] management strategies depend on the needs of the individual teacher . . . what works for one teacher can often be of help to another, and the heart of [a] support system lies in "pulling teachers together as a group" (p. 21).*

School Capacity and Access for Networking

Most schools lack the technical capacity to use more sophisticated access to the Internet. They do not have and cannot afford the basic hardware, connectors, and accounts, and policy decisions need to be made regarding who will ultimately pay not only to "hook up" the schools but also to maintain their accounts once they start using the Internet. This lack of resources for the foreseeable future is particularly acute for "resource poor" schools—which arguably are the very schools that need access to the Internet and its resources the most. For example, ease of use is one of Mosaic's (a gateway to the Internet) greatest selling points, but until ease of use is combined with the technical and financial capacity to run the Mosaic software and access the Internet, actual use will not occur.

Districts must first try to ensure that schools can access information over the Internet in as easy and affordable a way as possible. They should encourage the development of legislation and policies at the state level that would provide for basic funding of such access. There needs to be support to show teachers how access to an electronic network such as the Internet can improve practice, thus making the advantages of electronic networking apparent to teachers.

The point is that we can get teachers using the Internet now while still continuing to support and develop the more high-end technologies. If districts are successful in this first step, then when more complex services and technologies become more available and affordable to schools and teachers, they will be ready, able, and eager to use them.

Electronic Networking

Our recommendations concentrate on how states and districts can position themselves to help schools take an evolutionary approach to acquiring and implementing information technologies. This approach means advocating for the use of low-tech technologies such as Minuet (an easy-to-use interface for accessing the Internet) in addition to or in advance of state-of-the-art technologies such as Mosaic. It is our position that so-called "low-tech" technologies, which are already being used, can serve as the "advance guard" for full and widespread use of more advanced technologies. In taking a go slow approach, teachers first become comfortable in using technology, then use it and see its applicability in thoughtfully conceived stages before they invest in the next levels. Three low-tech technologies are e-mail, bulletin boards, and gophers:

- Electronic Mail (E-Mail) is one cost-effective method for helping teachers become acquainted with computer networks and to provide technical assistance to teachers right away. It allows quick and easy contact between users for the exchange of messages, data, and even software. Since Mosaic does not accommodate e-mail, teachers will need another type of software/interface in addition to Mosaic for connecting to the Internet and using e-mail.

- UseNet News comprises more than 2,100 electronic bulletin boards, where Internet users can post messages, engage in ongoing discussions, and request information/collaboration on specific topics. Examples of UseNet News bulletin board topics are "distance education," "K-12 science education," "K-12 mathematics education," and "educational technology." These bulletin boards are a very effective way for teachers to access individuals and organizations with expertise that could be used in the classroom.

- Gophers are sets of directories containing information from a variety of resources on a particular topic. Gophers are accessible to a great number of people and organizations worldwide via low-tech and widely available software and connections. They are a "here and now" opportunity to build interest in and use of a network—creating a base of users who will later access its resources via more sophisticated technology.

Electronic networks can and should be easy to access, affordable, and easy to maintain. They must also take on a life of their own and provide ongoing, on-line support for teachers when they want it and at their own convenience. This can only happen if teachers use the technologies as they become available in the school, integrate the technologies into their daily routine, and then demand the next phase. Showing use of a technology and the demand and applicability for next phase use will be strong arguments for continued and expanded investment. Technologies must not be adopted as add-ons, but as an integral part of achieving curricular goals.

Internet Access Now

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

- Mark Weiser, Xerox computer scientist
Scientific American, September, 1991

"Low-tech" does not mean lack of access to the benefits of networked information technologies such as the NII. For instance, low-tech technologies such as e-mail, bulletin boards, and gophers can act as a bridge to introduce teachers and educators in our region to the resources available on the Internet.

More sophisticated use will occur over time as teachers become familiar with what a technology has to offer.

Taking this approach would mean that large numbers of teachers could immediately begin focusing their attention on resources available to them to enhance their curriculum via these sources. We believe that this process represents a stepping stone toward use and realization of the benefits of "high-tech" technologies such as Mosaic when these technologies become more widely available and cost-effective. By combining the capacities of low-tech technologies currently accessible on the Internet, and other resources with high-tech technologies, but less widely available, we will build schools' capacity to access resources even as we build a need and a demand for those resources.

Just as experiences with ILS have shown, more sophisticated use will occur over time as teachers become familiar with what a technology has to offer. As noted by Mageau (1992):

> *[A] sophisticated level of use, such as being able to go in and choose and resequence lessons (an essential part of helping teachers fully integrate an ILS), is not something that teachers will immediately embrace. "It's often a function of time and use," says Charlotte Curran, the instructional coordinator for the Educational Computer Department for DeKalb County (GA) Public Schools. "The longer they have the system the more they are interested in what they can do with it." (p. 22)*

In other words, given time, support, and a system that supports their instructional goals, teachers will gradually become more adept at integrating technology into the classroom. Starting slowly gives teachers the chance to find out for themselves where, when, and how technology supports what they want to accomplish. It is when teachers internalize these ideas in this way that technology has a chance to become second-nature to the teachers and an integral part of the teaching/learning process.

School Development Resource System

The School Development Resource System (SDRS) is a research and development project underway at NCREL to produce an integrated set of research-based resources and a human support for school improvement. It is designed to provide school improvement teams with the research-based assistance that they need to address critical school development issues and to meet state school improvement mandates. When completed, the SDRS will comprise at least five components. While all of the components are important, we are initially concentrating on the development of the Critical Issues Server.

SDRS Critical Issues Server. This electronic information resource is the core of the SDRS. It offers to the school development team easy-to-find, concise, research-based information on critical school development issues. The critical issues documents are uniquely formatted to provide a quick, yet powerful overview of the issue. This server will reside both on high-density/CD-ROM disks as well as on the Internet. The power of using the Internet for this component is twofold: (1) The critical issues will be updated regularly with new research findings, and school teams will help us identify new critical issues enabling the most current thinking on school development to be constantly accessible; and (2) the format of the critical issues document contains hypertext links to primary documents, audio clips, top-ten research resources, and other Internet databases that can be accessed by clicking on icons or on underlined words.

School Development Library. Some resources cannot yet be transmitted electronically due to technical limitations. Subscribers to the SDRS will receive a library of materials — videotapes, audiotapes, the Strategic Teaching Framework multimedia system, books, and articles — that help users to explore deeply the SDRS critical issues. These resources are organized around the 14 school development areas and the University of Wisconsin Restructuring Framework.

School Development Facilitator's Guide. This guide is designed to help the teams leading school development as they work toward school improvement. By taking a problem-based learning approach, the guide offers advice on defining and tackling the most important school development issues. The guide will refer to important information found in the Critical Issues Server. Since much of the content is found in the server instead of in print, the guide will remain current for many years.

A strong school leader is required for any successful school improvement effort. The SDRS will proved a Leadership Academy for principals and other school leaders. The Facilitator's Guide will be used to guide learning in this academy.

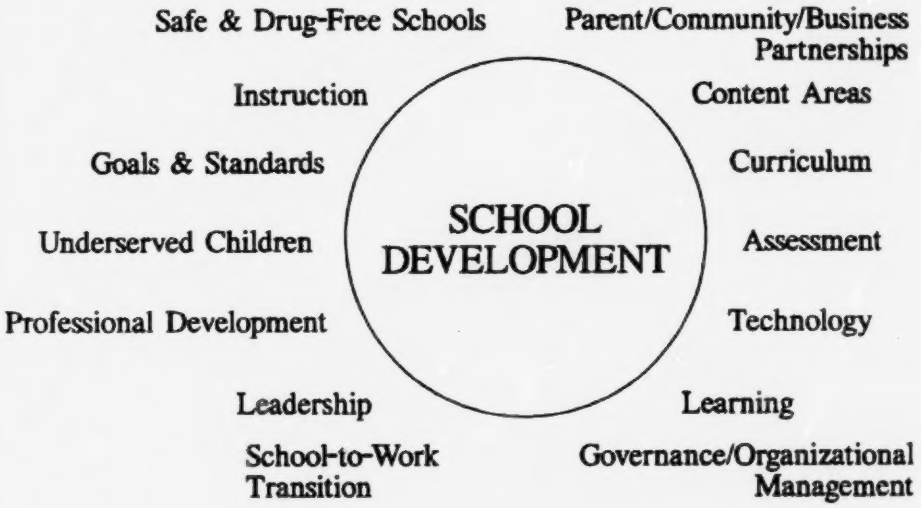
Human Support Network is supported through audioconferences, electronic bulletin boards, conferences, and e-mail via the Internet. An important component of the SDRS is the human network and the strategies for creating and sustaining a community of professionals involved in school development. This effort to build the infrastructure will require collaborations with agencies such as intermediate units.

Technical and Content Hotlines. 1-800 phone service will be provided for users who need help with the technologies involved in using the SDRS, as well as for answering content questions about school development. The goal is to reduce the need for phone support and to off-load those requests onto the electronic system.

What Is School Development?

What is school development? School development is the process by which schools define and sustain plans for their evolution and growth. Through school development, school improvement plans are formulated that focus on high standards for all children and that are comprehensive and systemic. These plans are sustained by and include key players and stakeholders, and they address national and state goals, standards, and outcomes. The goal is to create effective learning environments for all children.

In a way, school development is like learning and professional development. It is a nonlinear process for setting goals and devising strategies to achieve them. This process necessarily addresses a whole system of interrelated issues—working on some issues but not others is not sufficient. NCREL has identified 14 Critical School Development Areas:


Safe & Drug-Free Schools
Parent/Community/Business Partnerships
Instruction
Content Areas
Goals & Standards
Curriculum
SCHOOL DEVELOPMENT
Underserved Children
Assessment
Professional Development
Technology
Leadership
Learning
School-to-Work Transition
Governance/Organizational Management

What is the School Development Resource System (SDRS)? The SDRS is a collection of resources and human support for schools that are involved in school development. This Mosaic server is one source of those resources. On it, you can access the latest research-based information in each of the Critical School Development Areas. The Regional Educational Laboratories have organized bodies of literature and research around these critical issues that reflect our belief and position that school development cannot be a piecemeal process and still be effective. The SDRS also includes a videotape library, a multimedia professional development system, and audio conferences on school development. For more information about these components, send an e-mail request to sdrs@ncrel.org.

Professional Development

Of course, no technology brings about these reforms only by virtue of its existence. Student and teacher training is a necessary component of the process, especially if we are to avoid accusations that any given technology represents just another example in a long series of fads that were tried but never really implemented, tested, and evaluated because they were simply added to, and not integrated into, the routine of a school. Professional development must support teachers as they attempt to implement technology in the most efficient way possible as well as help them identify the most effective curricular models for their classrooms. Professional development, when viewed systemically, implies helping all teachers to increase their efficacy in the classroom by changing the way they interact with all students every day. Professional development must focus on learning strategies and approaches that build off of what is known about how children learn.

Professional development, when viewed systemically, implies helping all teachers to increase their efficacy in the classroom by changing the way they interact with all students every day.

We focus our discussion here on reasons why professional development is so very vital to successfuly implementing school reform and how applying technology for the purpose of professional development can become so much more effective and efficient. Interspersed, in boxes, throughout this section are examples of professional development activities using technology to support interactive and inquiry-based learning, which are being developed at the North Central Regional Educational Laboratory (NCREL). These serve as one set of examples illustrating what professional development to serve these purposes can look like.

Jane L. David (1992) encourages a focus on professional development in the use of technology in her chapter Realizing the Promise of Technology: The Need for Systemic Education Reform. She states:

> *The bewilderment of educators and policymakers about technology simply adds to the appeal of individualized, self-paced systems that require little, if any, teacher involvement. (p. 1)*

David takes the position that technology can be used to transform teaching and learning, with the driving force coming from well-articulated ideas about what "students should know and be able to do, how people learn, and, correspondingly, how schools and school systems should be organized." It is her belief that significant changes in teaching and learning will require significant changes in the entire education system. Supporting the changes in teaching and learning cannot be done without support from the entire system. Bob Beck, of the University of Chicago, has considered these issues as he has explored ways in which new technologies, including imaging technology, can and will be incorporated into the classroom.[15] According to Beck:

> *[T]he roles of teachers will change considerably. Although there is a danger of students becoming more and more isolated through the use of such technology, Beck instead emphasizes the possibilities that exist for teachers to bring students together in a collaborative atmosphere. Each student will have an individual contribution to make and will have experienced success on his/her own through the use of imaging technology. In addition, he/she will be able to share the learning strategies used. In this way, groups of students can develop team projects that draw upon the things learned and can work together to solve complex problems. Of course, he also makes the point that teachers will require training in the most effective applications of this technology.*

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David (1992) builds on this observation. As she points out, the new education, focusing on systemic reform, "captures a much more dynamic view of schooling in which teachers guide students through individual and collaborative activities that encourage inquiry and the construction of knowledge." In order for this type of change to occur, schools and the school system must be reorganized to support the necessary professional development of teachers. The emphasis is on continuous learning and improvement. Teachers need to model this continuous learning, and in order to model it they will need to be empowered by policies from both the district and the state. Empowering teachers is what technology in its best use can promote. Technology can be used to help teachers change practice to meet the new curriculum standards.

Jane L. David (1993, p. 14) promotes the following Rules of Thumb for Professional Development:

- Invest at least as much in professional development as in technology. If funds are limited, use what is available for professional development and seek other funding sources, including grants and business partnerships, for acquiring technology.
- Focus on ensuring teacher access to and comfort with technology for their own uses before expecting extensive use with students.
- Invest in developing principals as leaders of change, supporters of teacher development, and modelers of technology use.
- Maximize the leverage of professional development by investing in lead cadres of teachers—one or more from each school—who are supported to share expertise with colleagues, and in other trainer-of-trainers models.
- Give school faculties (as a whole, as teams, and as individuals) the flexibility to select the kinds of training and other development opportunities appropriate to their needs and preferences.

In order for this type of change to occur, schools and the school system must be reorganized to support the necessary professional development of teachers.

If students are to become lifelong learners, they will need to see it modeled by their teachers. Teachers will need to be trained in the kinds of practices that they will be fostering. This type of training will need to be ongoing and an essential part of the district's plan for change. Students should not be expected to do what their own teachers cannot, and teachers should not be expected to do what the administrators do not value, or support developing, or believe in themselves. Systemic implies changes in everyone; hence the importance of looking at policies at each level and how they coordinate, or should coordinate, with each other.

SCIENCE IMAGES: Achieving Goals and Educational Success

SCIENCE IMAGES: Achieving Goals and Educational Success is a visual library designed for use by K-8 teachers in professional development courses and workshops. It is being developed by the North Central Regional Educational Laboratory of Oak Brook, Illinois, in cooperation with General Learning Video of Northbrook, under a $735,000 grant from the Annenberg/CPB Math and Science Project.

Comprising nine videotapes and accompanying print materials, **SCIENCE IMAGES** seeks to improve science learning through improved teaching of science at the elementary grade level. The videos will offer content refreshers to teachers as well as illustrate the thinking behind science standards in actual classroom action. Four videos will focus on life science, produced for grades K-1, 2-4, 5-6, and 7-8. Another four videos will cover physical science. The ninth video in the library will provide a general overview on "Achieving Goals and Educational Success."

Print materials will include guidebooks on K-8 physical science and K-8 life science, a self-directed professional development guide, a professional development resource guide, an inservice facilitator's guide, and a promotional poster. The project, which began in January 1994, will be completed early in 1995. The date of product availability from the Annenberg/CPB Math and Science Project is not yet known.

The **SCIENCE IMAGES** library brings into an appealing, usable format five critical dimensions of effective science teaching:

- A focus on science instruction that is consistent with current research on learning
- The critical role of teachers' subject matter knowledge and disposition toward science
- Teaching that is consistent with the national science education reforms
- The contexts of teaching and learning
- A professional development planning process

The developers believe that as a result of viewing the general video and two or more programs appropriate for their students' age levels, studying all accompanying print materials, and engaging in the ongoing professional development activities as specified in the professional development guide, teachers will:

- Understand the fundamental principles about how children best learn science
- Be able to provide experiences so that children learn science consistent with their school's curriculum and the national science standards
- Be motivated to pursue ongoing professional development activities

The Annenberg/CPB Math and Science Project is an activity of the Annenberg Foundation and the Corporation for Public Broadcasting to improve math and science education using technology. The North Central Regional Educational Laboratory (NCREL) is a not-for-profit corporation working to improve education in seven Midwestern states. Now in its tenth year, NCREL has been producing national videoconferences with PBS since 1987.

General Learning Video is a division of General Learning Corporation, serving both corporate and school learners with a wide range of educational communications services. General Learning Corporation has been an educational publisher for more than 25 years.

Professional Development and Standards

The standards under development assume a restructuring of the process of teaching and learning. The NCTM standards, for example, encourage concepts such as fractions to be taught in such a way that children will understand real-world applications. They will be able to demonstrate their knowledge about where and when and how fractions are used in everyday life. Teachers will also understand what they must know and how they can demonstrate their knowledge in order to change the way they teach mathematics that will connect with content standards for students.

To build on this call for restructuring, teacher education programs must work with teachers, especially beginning teachers, to help them build a repertoire of strategies that incorporate this view of learning. However, it will be impossible to do this without exposing teachers to examples of teaching that exemplifies this kind of approach, although it is probably infeasible to physically bring novice teachers to classrooms where this teaching occurs. It may even be difficult to locate sufficient examples of understanding and applying the higher content standards; but the need for them is, and will remain, great. These examples are those of equity, of measuring progress toward the higher standards, of redefining what teachers teach and for providing new learning opportunities for all students, and of the necessary professional development to implement all of the above.

Technology is emerging as a method that makes it possible for the novice teacher to analyze live classroom instruction.

Given these considerations, technology is emerging in some arenas as a means not only for providing teachers and teacher interns with numerous examples of these classroom environments, but as a method that makes it possible for the novice teacher to analyze live classroom instruction. It is this analytic capability, available when examples of teaching are presented through integrated media environments,[16] that makes new teachers aware of what kinds of activities will be occurring in their classrooms and how they will have to work with students to help them build their own understanding of concepts. Barron and Goldman (1993) make the following observation:

> *Beginning teachers need help in learning how to observe teaching and learning, particularly if they are to understand how teachers in student-centered classrooms make interactive teaching decisions based on student thinking and understanding. Research conducted at Vanderbilt (Randolph & Everson, 1992; Risko, 1992) indicates that when videodiscs are used in methods courses to help students focus on factors that influence teaching and learning, preservice teachers are able to write richer, more elaborative descriptions of classroom video incidents than are preservice teachers whose courses do not incorporate the integrated media materials. Videodisc technology allows a complex classroom incident to be revisited over and over as novice teachers work with teacher educators (or mentor teachers) to isolate and examine different factors that influence teaching and learning.*

The implication is that professional development activities that use technology in this way—whether implemented through preservice or inservice—will be a necessary part of the process of putting the goals and standards into practice. Teachers cannot be expected to understand and incorporate methods and strategies that may be new to them without a chance to engage in this type of reflective activity. We must also keep in mind that approaching professional development in this way will also serve the purpose of familiarizing teachers with the contributions technology can make to the classroom environment. Barron and Goldman (1993) comment:

> *[I]f we expect teachers to use these technologies in their own classrooms to support active learning and problem solving, the teachers will need time, training, and opportunity to work with the equipment and software. Those who work with preservice teacher education programs have special opportunities and responsibilities to prepare teachers who understand both what technology can do and how to use the technology.*

As professional teaching standards continue to be incorporated into the standards developed by each of the curricular areas,[17] professional development, and the role of technology in professional development, will take on greater and greater importance.

What is STF?

STF (the Strategic Teaching Framework) is a multimedia resource designed to help educators improve their practice. STF users can view whole classroom segments and immediately access expert appraisals (audio and text), supporting research (text and graphics), and other kinds of relevant information.

Who is developing STF?

- STF is currently being developed by an NCREL and Indiana University partnership.

What makes STF unique?

- STF provides a library of whole class situations.
- STF provides expert commentary on several dimensions of each class.
- STF provides access to supporting research and other kinds of information.
- STF provides a 'hypermedia information navigation' strategy.
- STF provides an 'electronic notebook' for recording and sharing reflections.
- STF is a shell that can be used in a variety of teaching/learning applications.

What is the Conceptual Basis of STF?

The design of STF is based on recent research in cognitive science:

- *Context*: The meaning of any concept is determined by its use in a specific context. For example, developing an understanding of how and why a teacher uses a particular instructional strategy requires that the learner see the strategy within the context of the whole classroom.
- *Mental Models*: Research has shown that learners make sense of experience by constructing mental models. Professional action is influenced more by mental models than by principles or guidelines.
- *Multiple Perspectives*: In order to develop a rich understanding of a situation the learner must 'see it' from multiple perspectives. STF provides perspectives of various 'experts' such as the teacher, teacher educators, researchers, and administrators.
- *Complexity*: Developing rich understandings requires that the learner experience situations in their full range of complexity. An instructional strategy 'looks' different in a small, well equipped classroom than it does in one that is over-crowded and poor.
- *Multiple Representations*: Intelligence is multi-dimensional. It includes the familiar mathematical and verbal intelligences as well as visual/spatial, kinesthetic, interpersonal, intrapersonal, and musical. Learning resources must represent content in may forms.
- *Reflection in Action*: To develop new skills, learners must act, see alternative models, hear expert appraisals, and reflect on experience and cognitive development.

Who will use STF?

STF is initially being designed to provide effective models of teaching to in-service and preservice teachers. It provides schools with the resources to create their own professional development program to meet the specific needs of the school.

For more information contact Randy Knuth at NCREL, 708/218-1069.

Professional Development and Project-Based Learning

Pogrow, 1990; Stearns et al., 1991; Tierney et al., 1992; and Zorfass et al., 1991 have shown that in project-based attempts, technology can be used to transform teaching and learning. Technology can be effectively use to engage students in constructing their own learning through inquiry-based instruction. However, in the Higher Order Thinking Skills (HOTS) Program, Pogrow (1990) emphasizes that the software and technology appear to function as motivators, and that, although learning to use them may be the platform for applying thinking and problem-solving skills, the technology itself does not deliver the instructional strategy (Herman, 1993).

Translating the success of these small projects into changes on the larger scale will require not only an investment in technology, but an even larger investment in teachers.

According to David (1992), the key to the success of these projects lies in providing "ongoing assistance, facilitation, and professional development to teachers in support of transforming their practice." The support provided to teachers becomes very much like the kinds of support that teachers are going to have to provide for students. Translating the success of these small projects into changes on the larger scale will require not only an investment in technology, but an even larger investment in teachers. J. W. Little (1992) states:

> *Opportunities for teachers, like those for students, need to be authentic and collaborative tasks, like curriculum development, not traditional menu-driven workshops and packaged training programs.*

Professional Development and Networks

It is possible to work with teachers on these skills in a number of ways. One way that has been found to be very effective is the use of networks. This finding is an especially promising one because not only does it mimic the kinds of tasks teachers would be using in the classroom, but it can also take advantage of the kinds of connections that technology makes possible. For example, through the Foxfire Teacher Outreach Network:

> *teachers become active learners, participating the way students do: choosing a project, planning, doing the work, assessing the outcomes . . . . Teachers who identify with the Foxfire approach to learning try it out in their classrooms and then seek professional affiliation with the network. Thus teachers model the kinds of learning and involvement they hope to elicit from their students. During the periods between their formal regional meetings, Foxfire teachers keep in touch with one another and with the mission of their educational collaboration through publications, correspondence, and electronic communication (Lieberman and McLaughlin, 1992, p. 674).*

Through these kinds of professional development activities, as opposed to traditional lecture-style inservices, Lieberman and McLaughlin point out:

> *teachers work with others who are struggling in similar ways to learn new material and to try out different approaches for reaching students. (p. 674)*
>
> *The context in which educational change is pursued is everything . . . . [N]etworks concentrate on building communities of teacher/ learners. It is thus critical that policy makers and others approach teacher networks not from the standpoint of management and control, but from that of the norms and agreements of communal relations. (p. 677)*

Professional Development and Organizational Structure

The same technology will be differentially effective depending upon the setting. This condition is due to the fact that, as McLaughlin (1987) points out:
[i]implementors at all levels of the system

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> *effectively negotiate their response, fitting their action to the multiple demands, priorities, and values operating in their environment and the effective authority of the policy itself. Further, this bargaining or negotiation is a continuous process, proceeding over time as policy resources, problems, and objectives evolve and are played against a dynamic institutional setting. This means that the nature of the bargain will change over time within settings and will most likely differ across units of the policy system. (McLaughlin, 1987, p. 175)*

This difference in effectiveness should not be surprising. Berman and McLaughlin pointed out in 1977, and it still holds true today, that

> *[n]o class of existing educational treatments has been found that consistently leads to improved student outcomes when variations in the institutional setting and nonschool factors are taken into account. (Berman and McLaughlin, 1977, p. v)*

Any school that implements policies concerning the integration of technology—whether they emanate from the federal, state or district level—will find that, in addition to questions of capacity, it will have to confront issues of will. As McLaughlin (1987) stresses,

> *will, or the attitudes, motivation, and beliefs that underlie an implementor's response to a policy's goals or strategies, is less amenable to policy intervention. (p. 172)*

Thus, the entire organizational structure, its systemic qualities—including the inclinations of the individuals who will have to implement the policy—must be focused on shared goals in order to ensure the success of any program that seeks to implement educational applications of technology. We know of no other way of accomplishing this goal than having long-term commitment, through training and other resources, institutionalized by the leadership at the state, district, and local levels.

Any school that implements policies concerning the integration of technology will find that, in addition to questions of capacity, it will have to confront issues of will.

Summary of the Mathematics and Science Consortium Initiatives

Enabling change in mathematics and science education: A leadership project for professional development providers

The 1993-94 follow-up professional development activities and planning continues within each of the seven participating states. Technical assistance and on-site facilitation/ consultation by NCREL/MSC staff is being customized to meet the needs of each state and to integrate the numerous state and local efforts with similar goals.

The Cognitively Guided Instruction (CGI)/Regional Educational Laboratory (REL) National Dissemination Project

CGI is a Professional Development Project that reflects a philosophy of teachers making instructional decisions based on their knowledge of individual children's thinking. Currently in its seventh year of funding from the National Science Foundation, CGI was started by Elizabeth Fennema, Thomas Carpenter, Penelope Peterson, and Megan Franke as a research program to investigate the impact of research-based knowledge about children's thinking on teachers and their students. The project currently includes investigation of children's and teachers' thinking in grades K-3, the study of CGI in urban schools, and the study of the impact of CGI in pre-service education.

The primary goal of the CGI/REL National Dissemination Project is to provide K-3 teachers nationwide with the opportunity to construct detailed knowledge about children's mathematical thinking and to link this knowledge with instructional decision making through a comprehensive professional development experience. The Wisconsin Center for Education Research in collaboration with the national network of Regional Educational Laboratories is currently in the process of creating a multi-year plan and submitting a new proposal for national expansion and extension of CGI. Todd Fennimore, of NCREL, and Donald Chambers, of WCER, are the primary authors of the grant proposal; however, each Regional Educational Laboratory is designing a dissemination plan that uniquely reflects the needs and infrastructure of their region. In the NCREL region (as with many other regions), we see the IUs playing a very critical role in the collaborative planning and implementation of the dissemination and effective professional development of CGI.

Project 140K: A collaborative professional development initiative for the improvement of classroom assessment

Project 140K is a collaborative professional development project currently being designed by a team from the Mathematics and Science Consortium at NCREL and representatives from each of the seven states in our region. The primary goal of the Project is to take advantage of the strengths and current research-based classroom assessment initiatives in our region and nationally in order to improve and increase the authenticity of K-12 assessment practices.

Seven state assessment leadership teams each composed of twelve teacher-leaders, curriculum specialists, professional development providers, assessment specialists and other educational leaders (regionally representing each state), will begin by participating in a Summer Leadership Institute, July 14-17, 1994. The content of the Leadership Institute will be a balance of: 1) modeling classroom strategies for linking curriculum, instruction and assessment through performance tasks and questioning;

2) learning about issues related to the design and implementation, as well as impact, of authentic assessment tools; and 3) designing and implementing effective professional development. Teams will also be involved in developing an action plan for improving classroom assessment "back home."

Note: The Assessment Toolkit (shared with you at the last IU meeting) is a resource of the Regional Laboratories and, along with a variety of other resources, will be used in this project. The **MATHA Professional Development Project** was originally developed as an MSC/NCREL and Indiana State Department collaborative and is being used as a draft model in the Project 140K design.

Pre-conference: Linking assessment with teaching and learning in mathematics and science

This assessment pre-conference to the Ohio Conference on Teaching and Learning (March 1-3, 1994), being held on February 28, 1994, in Columbus Ohio, is being jointly sponsored by the North Central Regional Educational Laboratory, the Math/Science Consortium, and the Ohio Department of Education. The focus of the conference is on teaching and learning as it relates to students' ongoing, real life learning, and alternative assessment's role in informing and refining the teaching and learning process. Targeted to meet the needs of a broad audience, including teachers, administrators, parent/community members, and policymakers, the program will model principles of effective adult learning through both large group and small group sessions designed for active involvement and critical discussion. Over 50 sessions will address a variety of assessment related issues.

Section Three

Looking To The Future

The next section will explore the possibilities of creating alternative ways of connecting telecommunications and information technologies to as many schools as possible as quickly as possible. We will be discussing public/private ventures, developing a regional market for education, opportunities for the federal government to invest, and the concept of an educational utility.

The Case for Public/Private Ventures

Time and again, policy studies point out that education has no place at the table when decisions are being made about the use and application of technology. We know this situation exists, but what accounts for it? Part of the answer lies in the continuing struggle to maintain adequate levels of funding for education. With more and more states unwilling or unable to equitably fund education, with more and more local areas finding it impossible to raise property taxes or to pass bond issues, it is no wonder that schools find themselves cutting back on traditional programs, much less even being able to consider planning for and investing in telecommunications and information technologies.

If we believe that technology should be looked upon as a basic requirement in the schools, and if we acknowledge that conventional sources of funding are no longer available, we are put in the position of being forced to identify other means by which to help schools appropriate technology. One of those methods involves linking public education with private enterprise—public/private ventures—to accomplish goals that are recognized as important to the future health of our nation's economy and educational system on both a short- and long-term basis.

There are a number of forms that public/private ventures can take, as well as a number of different ways to approach the melding of technology and education. The basic question when considering large scale public/private ventures is, How will it be possible to provide needed technology services to meet curricular goals given the minimal technology planning that schools have engaged in as well as the nearly bankrupt condition of many state and local economies?

Linking public education with private enterprise to accomplish goals that are recognized as important to the future health of our nation's economy and educational system on both a short- and long-term basis.

Actively Partnering With the Private Sector

Proactively partnering with the private sector will ensure that education's systemic problems will be addressed more adequately within a region. From a company's perspective, the benefits of partnering with education can be great and are often neglected. Short-term rewards might include more effective employee education programs, positive public relations, and expanded training facilities. For the long-term, the payback can be potentially greater as students will enter the job market better able to meet the challenges of the marketplace.

From a school's perspective, partnerships can also offer a variety of significant benefits. One advantage is that such a relationship enlarges the world for students by offering opportunities outside the classroom, mentor/tutor programs, interesting and relevant curriculum materials, and exposure to the latest technologies. Another advantage is that a business/school partnership can provide added resources for professional development for teachers. Teachers can use such resources as a means to increase their knowledge and skills by working in summer research positions and applying for and receiving grants and endowments for innovative programs, training, consulting, or further research. Additionally, schools can leverage corporate experience with organizational and management issues. Strategic management, team-building, information management, and marketing are all areas of corporate expertise that can be readily applied to a school's unique circumstances.

Oftentimes, technology can serve as the common denominator between a school and a potential business partner. Both rely on technology to help educate their staffs and improve their working environment and both can reap benefits from technology acquisitions—especially when it is a technology that is available to students during the day and to employees and extension program students in the evening. Such technology that can support the learning goals of both students and employees offers an excellent place to begin the creation of a business/school partnership.

Technology can serve as the common denominator between a school and a potential business partner.

Such partnering is not a new concept. In fact, back in 1986 the National Alliance of Business started a project on education improvement that has since generated some important lessons in this area. Their experience led to the conclusion that, though partnerships can be difficult to initiate and sustain, the chances for success are greater if the following conditions exist:

- Partners agree about the nature of the problems and share common vision for the future
- Businesses and schools already have a history of working together
- Partners use an organized structure to coordinate the efforts of the partnership
- Partnerships have the involvement of top leaders from business and education
- Partners focus on short-term goals but commit to sustained, long-term relationships
- Goals are clearly defined and measurable

The Curriculum Network (TCN)

One example of a public/private venture that attempts to follow these guidelines is The Curriculum Network (TCN).[18] TCN is a partnership between three public agencies (North Central Regional Educational Laboratory, Far West Laboratory, and Pacific Mountain Network) and one private company (Screen Media Partners) created for the purpose of enhancing education through the use of technology and telecommunications. The technology it will provide to schools will result in a direct and tangible benefit. Teachers will gain an added understanding of the standards related to their curriculum as they integrate the curriculum standards supports units within CTM.

The partnership assumes that curricular needs must drive the choice of technology and that technology is an effective format for delivering the curriculum. TCN cannot be all things to all groups but it proposes to address the equity/access issue that continues to be a problem with respect to technology. One could continue to work with technology rich schools districts such as Glenview (IL) and Palo Alto (CA), but pursuing that course won't address the fundamental disparity of educational technology between the "haves" and "have-nots" in our states.

There won't be one way of funding the integration of technology into our schools. There won't be one technology that will be used by schools. There won't be just one format for information used by schools. TCN will be one of many options to schools, but we think it is one that keeps the issue of equity/access at its core because it makes base-line, entry-level equipment and content available on a widespread basis to all schools that participate.

TCN Technology

The telecommunications capabilities of TCN that need to be stressed are as follows:

- The project proposes to provide on-line services to the schools.
- Networking through the Internet will be part of the design package
- Schools that have no technology at all will receive initial base-line equipment and wiring for the cost of the subscription, as well as potential access to information services.

The technology package that TCN proposes to make available to schools will include four core elements:

- An "open" system architecture Central System Input device that will provide each school access to:
  - Out-of-school signals from:
    Cable
    Satellite
    Broadcast
    Databanks
  - In-school signals from:
    The public address system
    In-house video camera(s)
    One or more VCRs, laser disc players, etc.
- A central workstation where teachers can access information from a variety of formats, combine it into a single unit, and record it on videotape for playback in classrooms
- Classrooms linked by a local area network (LAN) with a central video and data storage/playback device that feeds materials to individual classrooms
- Television receivers and a videocassette player

This arrangement will allow for teacher flexibility in using a variety of technologies and accessing information when they want and need it.

Reaching the classroom

This venture was designed to offer regionalization of content in a video medium. Its historical predecessor was PM Magazine, a series which allowed the local market to add material to the core elements in order to tailor it for their audience. The format was organized in this way so that material could easily be added, particularly to the introduction and concluding sections, using a local area host. Another part of the design process for TCN calls for teachers to contribute to the development of content for the curriculum support units. What teachers say and experience in the design process drives the outcome. What this project proposes to provide is technology that's customized to a school and teacher and content that's regionalized.

TCN proposes to be a technology system that reaches the classroom and individual teacher and does not require a huge cost on the part of the schools. It does not require the school to have a certain level of technical sophistication or minimum level of technology. The system that each school receives will depend upon their needs. Each contract will be tailored to the school's needs within the context of what is being offered. Print support materials for the curriculum support units will be provided and teachers will receive professional development training on an ongoing basis, with a staff member trained for site-based assistance, and a video database on training as well as an "800" hotline number made available.

How will it work?

Interested junior high (7-8) and high schools (9-12) will subscribe to TCN and receive a library of Curriculum Support Units (CSUs)—seven to ten minute mini-programs combining audio and full motion video, which establish the links between identified curriculum areas and real-world reference points. The curriculum can be customized for individual regions. Teachers will decide which CSUs they wish to use and when. In-depth training will be included to help teachers best utilize the technology and the units. However, the teachers must agree to use on average one support unit a week because approximately 50 percent of the cost of the project will be subsidized through underwriting messages similar to those on public broadcasting stations. The rest of the cost will be covered through allocations from the federal, state, and local education agencies as well as foundations.

An interconnected workstation will provide teachers and students with the opportunity to access information and training from a variety of sources, such as the NII and cable broadcasts, along with various other media. Materials from these sources may be collected for later use or "piped" directly into the classrooms. Because TCN has no proprietary interest in any specific hardware, the most appropriate technologies can be provided at the most affordable cost, while meeting the individual educational needs of each participating school.

TCN is not the only solution for the technology woes of education. However, technology will be unable to impact the classroom at all unless teachers and students have access to it. TCN is one way of making sure that access is available and that it contributes positively to the educational experience. A variant on the Whittle, Channel 1 approach, this strategy takes advantage of the ability of private and public sector companies to advertise, but controls the nature of that exposure and lashes it to curriculum rather than news shows.

Leveraging Resources for Education

Barry Horowitz, chief executive officer of the Mitre Corporation, in the October 1993 issue of *The American School Board Journal*, identifies five areas that are key to successfully obtaining and integrating technology into the schools.[19] They include establishing technical standards and aggregating demand, as well as training teachers, and developing processes for getting high-quality hardware and software into the schools. The stronger the coalition, the larger the constituency; and the louder the voices advocating for full-inclusion of education as a participant in the creation and exchange of information through the use of telecommunications and information technologies, the greater the chance that education's needs will be met most effectively.

Telecommunications adds value mainly by making people more effective. It is not just an investment in technology; it is one in enhancing human performance. As discussed above, the technological capabilities of the new telecommunications systems are only part of the picture. More important is what we do with these new capabilities. Just as information technologies can bring new productivity to business organizations, they can do the same for the public service sector, especially education.

The idea of accepting that telecommunications and information technologies ought to be considered as parts of the infrastructure would imply that investment in these areas must be seen as strategic investments by state and local agencies.

In education, the problem is one of diffusion of innovations into traditional and bureaucratic settings. In addition, we have a widely dispersed number of schools. Hence, the advantages to applying telecommunications and information technologies to education would be wide coverage, rapid information dissemination, instant feedback, access to files, and electronic mail, resulting in a shared knowledge base and the ability to provide help and support unaffected by geography.

Planning for and implementing educational technology systems can be a costly and time-consuming endeavor. Many state and local agencies feel that they are ill-equipped on their own to adequately address the demands that these activities place on them. They recognize the need for educational technology, but they often feel that they are without any clear guidance on how to analyze and anticipate their needs in this area. However, the idea of accepting that telecommunications and information technologies ought to be considered as parts of the infrastructure—like roads, water systems, and education systems—would imply that investment in these areas must be seen as strategic investments by state and local agencies.

We also know that state and local agencies need specific kinds of assistance depending on the amount of funding that is readily available to them and the sophistication of the level of planning and implementation that has already occurred. Few entities, however, can afford to engage in these activities independently without substantial financial assistance, whether locally provided or tapped from other sources such as the government or business and industry. It is because of these conditions that regionality emerges as an attractive option in this arena.

Many educators and policymakers acknowledge that it pays to pool resources when engaging in similar sorts of activities or when trying to address similar needs. Such sharing can cut down on the amount of duplication of effort that occurs and allows different entities to learn together, as well as from each other, and this interconnectivity leads to the development of infrastructures. We argue that the development of regional infrastructures for investing in telecommunications and information technologies makes sense if there is to be connectivity to the interstate or national information infrastructure. It also makes sense if states and local agencies want to create regional education information infrastructures instead of regional information infrastructures that serve a variety of social service agencies. Conversely, if one uses education as part of a large social program, then regional information infrastructures do make sense.

Regional Consortia

If investment in telecommunications is being seen as important by more and more cities, states, and the federal government, then investing in an education strategic information infrastructure at a regional level is a wise decision. An underlying regional information access strategy that focuses on providing information to state education agencies, districts, schools, and teachers via technology can be a cost-effective way to restructure education systemically. Through a regional information infrastructure, education agencies can restructure the education marketplace to design technological systems that can develop and make accessible to students a wide variety of information and provide sustained training for teachers.

Horowitz (1993) argues the case for an education technology enterprise:

> *The right way to (help schools create an education technology enterprise that puts top-quality hardware and software in the hands of students and teachers) is to stimulate the formation of regional consortia of school districts that would work closely with industrial partners and the nonprofit organizations that serve the education community. These consortia—which might consist of all the school districts in a state, the districts in part of a state, or school districts from several states—should organize themselves in groups large enough to be influential and effective but not so large as to be unmanageable. The consortia would buy instructional software, create communications networks, develop teaching and training methods, develop effective techniques for administrative management and support, and identify and advocate specific scientific research needs. (p. 36)*

Presently, state education agencies and local school districts have little leverage in the marketplace for technology, sometimes even within their own state, when other agencies are competing for technology dollars and access. With a regional market, the potential can be maximized to develop large-scale public/private ventures,, driven by curricular and student needs, to help pay for the technology systems.

A regional approach for restructuring the education market not only assures reduced prices for any investment in technology but also assures fewer and less costly problems of interfacing and expanding as the needs and/or the resources allow.

This regional emphasis could create an environment where education has increased control in articulating demands and shaping the supplying of instructional materials to the marketplace.

Locally controlled and managed public schools cannot build the infrastructure necessary to make technology an integral part of the day-to-day activity in public schools and their communities. Through a regional education marketplace, states, hence, schools can aggregate a market for education technology attracting private investment in schools on a much broader scale. In addition, a regional consortium could more cost-effectively develop methodology and curriculum to train teachers to integrate technology and help learn new strategies to aid students in achieving the higher content standards across disciplines. A regional consortium would allow partnering with private industry to develop high quality educational materials and standards for developing, selecting, and purchasing materials and technology systems.

This regional emphasis could create an environment where education has increased control in articulating demands and shaping the supplying of instructional materials to the marketplace. In this scenario, the needs of education are put before the technology development and will influence it.
The question is not whether we ought to develop a regional information infrastructure, but rather how we can create an effective multistate network to implement cost-effective telecommunications and information technologies in the schools and who,

in the private sector, we ought to partner with to accomplish this aim.

A regional information infrastructure for education assumes that the access to this infrastructure will be available to each school and brokered without reliance on property taxes. Such a networked information infrastructure ought to provide each school and each classroom with the best research-based curriculum, instruction, and assessment resources in a multiple platform access. But, in order to accomplish this task, we need to develop interstate educational alliances.

The implication is that, by actively participating in the development of the NII from a position of strength, our educational leaders will help ensure that K-12 policy issues will be addressed as part of the development of the NII, keeping the concept of lifelong learning at the forefront for all citizens.

The classroom will become more closely linked with real-world activities and situations that allow for more active learning.

Advantages to becoming participants in the development of the NII early are many. For example:

- **Students** will have access to better models of teaching, better and more choices of instructional resources, and greater opportunities to access information.
- **Teachers** will end their isolation in the classroom and have available to them more resources and opportunities to obtain information quickly as well as be connected to staff development activities which, beforehand, would have been expensive to obtain. Telecommunications will provide greater access to parents since it will relieve the problems of scheduling visits and keeping parents informed.
- **Administrators** will have more resources for planning and managing the day-to-day activities and events of the school. They will be able to contact parents more easily, have more access to data, and be better able to track progress and present information in a more coherent, timely manner to a wider audience.
- **Parents** will have more of an opportunity to become involved with the school and will be able to choose more efficiently how their involvement should take place.
- **The Classroom** will have new capabilities that will extend its community beyond the school to provide students and teachers with extended learning opportunities. The classroom will become more closely linked with real-world activities and situations that allow for more active learning.
- **The School** will be able to incorporate technology into its day-to-day teaching experiences. More important, by integrating technology into its curriculum, the school will be preparing children to succeed in the new information job market. Careful planning will allow the school to become more of a community resource by extending its operating time to allow for the use, by the community, of various databases. In this way, a carefully designed shared-usage plan for the school's technology would create an enhanced economic infrastructure as well as a more effective education infrastructure for the community and thereby increase the value of real estate in the community.

Creating a Regional Information Infrastructure

In addition, as Horowitz (1993) suggests, this approach creates an environment where education has substantial control relative to shaping demands and building the educational technology marketplace. In this scenario, education is the driver in a proactive and aggressive mode. This allows for customization of content and services so that districts, schools, and classrooms will be better able to access them and, hence, use them and further customize the resources and materials to fit their own needs. As suggested, once there is agreement that all students will have access to the NII, then it is imperative that the regional infrastructure be developed as an open system.

Such an open system would allow schools to tap into an extensive network and be part of a system where they can expand their technological capabilities as the need for more sophisticated technology evolves. Once the regional information plan and technological infrastructure are implemented, there are several other economies of scale to be gained. For example, this infrastructure could provide every school in the region with access to research-based materials, instruction, and assessment. In addition, the region could provide access to courses such as the Algebra Project or to courses that focus on target audiences in urban or rural settings, as well as making it possible for individuals to extend their education. Lastly, students could be more economically linked to ways of assessing performance for district, state, and national purposes. A regional approach to assessment would cut costs and provide schools with more accurate and timely information concerning their accomplishment of academic goals.

These technologies, when well integrated into a regional plan, will have the greatest impact (relative to any other process) at solving the problems of outmoded curricula, bankrupt school systems, and the inequitable distribution of quality instructional materials. Regional cooperation through technology and interstate collaboration offer the possibility of creating a consortia to cost-effectively address our most persistent educational problems, particularly those related to poverty and helplessness.

There are several reasons why the development of such a regional system will benefit our schools.

First, no state is currently positioned to leverage all of the available and appropriate technologies. To date, individual states have not taken the same approach to developing technology policy and investing in a statewide technological infrastructure. A regional plan and infrastructure could enable the leveraging of multistate resources and multistate vendors to address issues of fiscal economies of scale and of equity and access for all students in the Midwest, especially those who live in urban and rural areas. By pooling their assets, states in a region such as the Midwest can leverage their resources for training, professional development, and technical assistance. There is no reason why efforts should be duplicated and dollars wasted. Likewise, a regional plan allows states to leverage resources for software acquisition as well as research and development.

Secondly, a regional plan would enable states to collectively address issues of hardware and software standards, thereby ensuring the development of an open-ended educational infrastructure. There is no reason why individual states should exhaust scarce resources developing state-specific technology plans when such technology is merely the means for addressing common educational concerns that stretch across a region. Once strategies, standards, and accountability measurements are agreed upon among a region's states, the learning curve and the cost for training drops, thereby enhancing productivity and the likelihood that national standards can be integrated into local curricula.

A regional plan would enable states to collectively address issues of hardware and software standards, thereby ensuring the development of an open-ended educational infrastructure.

A third advantage of a regional effort is the fact that states will have greater power both in the marketplace and as federal grant-seekers. A regional plan to compete for federal dollars supporting educational research and development would lend added credibility to regional proposals by showing that grant dollars would generate broad applications and have a significant impact. At the same time, such a unified regional alliance would provide member states with greater political clout at both the state and federal level and improve their ability to influence the development of legislation and the appropriations process.

In a similar manner, the development of a regional approach positions each state as a member of a regional "market." Currently, individual states and communities have no real leverage in the marketplace for technology. A regional plan would enable each state to maximize its potential to develop large-scale public/private ventures driven by student needs that would help pay for hardware and curriculum software. This regional approach offers the possibility of reduced prices for any investment in technology, and assures fewer and less costly problems of interfacing and expanding as the needs and/or resources allow.

Relative to any other feasible option, an effective plan to provide a regional information infrastructure has the greatest potential, on a large scale, to foster change in a way that will move us closer toward providing a quality education for all students on an equitable and content-specific basis.

What Might Such a Regional Information Infrastructure Look Like?

An education utility

Gooler (1987), in a book entitled *The Education Utility: The Power to Revitalize Education and Society*, writes:

> *The Education Utility signals the start of new ways to conceptualize and deliver educational opportunities for young and old alike in this country . . .; it is meant to open the doors to the world's information resources, for every individual learner, as well as provide a means for learners to connect with each other, creating a true learning society . . .; it is an electronic delivery and management system that will provide instantly, to the desks of educators and students . . . massive quantities of continually updated, instructionally interactive information (software programs, databases, sophisticated graphics capabilities, news services, electronic journals, electronic mail, and other instructional and administrative materials). All of these materials will be stored or accessed through a main "host" computer. Individual educational sites (school buildings, etc.) will be connected via a state network to that main host . . . through whatever communications channels are most easily and inexpensively available. Each education site will have a special site-based computer permitting storage of any of the materials or services the local site wishes to obtain from the host . . . Each instructional setting (such as an individual classroom) will also have a storage and switching device connected to the site-based storage computer . . . In addition the Utility will permit students and teachers to communicate with other students and teachers within a local area or anywhere in the world, through electronic, inexpensive mail . . . . Furthermore, teachers and administrators will have available a full range of administrative management and communication tools via the Utility. (Chapters 2 and 3)*

Essentially, this Utility conceptualized a system that offers a repository of information at the "front-end"; microcomputers located in individual classrooms, offices, continuing education centers, and so forth; a transmission system; networking features; teacher stations; administrative work stations; links with home stations; and a possible revenue source as the schools sell off excess capacity. It offers a logical step in the use of telecommunications and microcomputer technologies in education, building positive cooperative relationships with corporations, educational institutions, and communities to make the information resources available to anyone.

This concept was one vision of creating a community learning network that would be accessible to all schools and surrounding community facilities. Such a network would be responsible for managing a delivery system to and from some central host and regional repositories. The regional repositories would capture and send the flow of data, voice, and video images to school classrooms and remote sites. This integrated information system could be composed of a variety of technologies including e-mail, computer-assisted programming, interactive audio/audiographic technologies, interactive video programming, and both live two-way and one-way interactive video technologies.

[The Education Utility] concept was one vision of creating a community learning network that would be accessible to all schools and surrounding community facilities.

It is not difficult to see how this concept fits into developing a regional information infrastructure. It does not rely on a single technology but rather a combination and integration of technologies to provide educational information and resources to classrooms. The distributed storage and processing capability could provide educators, students, administrators, and the community at large a variety of information resources and allows for easy salability and upgrades. It could take access to learning outside the classroom to anywhere. It would have a completely open architecture and would be compatible with most hardware and software. Most important, the system would be user driven, serving as professional development for teachers, vocational/career preparation, higher education, continuing professional education, community needs, and corporate education and training. It could be the basis for a partnering of communities, businesses, and schools to provide education services, training, and professional development on a large scale using technologies, with community and business paying to use the system and subsidizing education through their usage fees.

Gooler writes about the development of several support systems within this design such as a research, development, and training center; a network of demonstration centers; linkages with professional associations; research and development centers; and governmental bodies. This could provide educators with best practices in curriculum, instruction, and assessment; multimedia prototypes of the relevance and applications of developing content and performance standards; rural and urban schools applications; multicultural education applications; and a library of units of instruction customized for the region. This concept, if developed to its ultimate potential, would redefine instruction, learning, the classroom, the schools, and ultimately education. It would help to achieve systemic education reform and enhance learning and learning opportunities in a cost-effective manner.

Why This System?

A large capacity central server like the utility model advanced by Gooler (1986) will produce cost savings in materials for schools because:

- A single copy stored at the server of a resource can be accessed by thousands of students anywhere, at any time. Problems of access and scheduling that are currently the bane of many long-distance education systems could be eliminated.

- It provides for a very high number of on-demand users, including the travel industry, the real estate industry, and the entertainment industry, who can perhaps pay for the usage by public education.

IBM's Eduport

A similar concept is being developed by IBM. Basically, at the heart of the system, they have a very large capacity (supercomputer) multimedia server and the capability of interactive TV via telephone lines. The server can provide for multiples of thousands of users who can concurrently access the system. Many students from many schools could access information simultaneously, hence supporting learning communities anywhere at any time for a variety of reasons.

IBM's vision is a large scale, centralized, widely available network operating with a basic cable infrastructure with video compression capability at the computer, allowing for an easy transition to a digital fiber optic system when the schools are ready and/or able to do so. It can provide multimedia-on-demand cheaply, which will create a market for high-quality multimedia instructional packages that a regional consortia could influence.

Serving Education

As far back as 1983, David Hawkridge (1983) emphasized,

> *If the new information technology is to come in to education, it must do so despite its costs rather than because of them. (p. 179)*

While we agree that education will have to invest in technology, we believe there are creative ways that can leverage dollars and resources to create an incentive and an opportunity to make information technology a part of education. The following are some examples of ideas that are in various forms of development and deployment in education. We view all of them as possibilities for education to become a proactive leader in using technology to leverage school reform equitably.

In order to take advantage of capabilities such as those just discussed, it is envisioned that at each school there would be a multimedia work station and a server. The central server capability would allow all schools (not just a few) to have interactive TV capability. The heart of the system is the capability to save anything and to serve anyone's needs, anywhere, at any time.

For our purposes, we would advocate regional servers, one in each state, or multiple servers in each state (the cost analysis is yet to be done before deciding on the best method). The end result is that each school would have access to a server. One way of addressing the cost issue is to develop partnerships with Department of Energy (DoE) labs, such as Fermi and Argonne, to develop integration of the video database and to donate processing time from their supercomputers. This is made easier because of existing federal legislation in the Department of Defense (DoD) authorization and appropriation bills that mandate that the federal DoD and DoE labs must have education programs linking with elementary and secondary schools, as well as the new compact endorsing efforts to link the DoE Labs and the ED Labs in cooperative efforts.

IBM is offering the network infrastructure. About 60 percent of schools have access to cable, and many still have the last mile problem; that is, wiring the classrooms. Telephone lines are a problem when they have switches unable to handle high speed lines. A regional education information infrastructure could work with IBM by offering to develop and provide content to go over the network that will be accessed by teachers who could then customize the content to meet their needs. The regional education component could focus on developing/brokering and/or providing educationally relevant multimedia content.

The central server capability would allow all schools (not just a few) to have interactive TV capability.

There Are Many Appealing Aspects to Multimedia On-Demand

The unprecedented success of Whittle's Channel 1 has shown that schools want access to technology. However, simply providing access does not guarantee enhancing the quality of instruction. There exists a wealth of stored information resources, but the ability to access them electronically by teachers is difficult and frustrating, and in many cases costly and limited by the school's local network capacity. The challenge is to make access simple and to include capabilities such as simultaneous access by many users of on-demand, full-motion video. It is characteristics such as these that make the utility concept so compelling for education and the formation of regional information infrastructures. It could create the leverage necessary to finance the system and to influence the development of content that will be provided to education.

School Improvement Plans are often difficult to implement because access to other teachers, information resources, and to experts outside of the school are constrained by traditional teaching schedules. A reconfigured curricula that relies on telecommunications and information technologies will make it possible for teachers to access resources from their homes using their TVs and telephones. No new learning of technology is required, no setting up of schedules or libraries of information for access need be developed or maintained.

Teachers can then get together and discuss what they have learned and what they have tried in their classrooms at convenient times. The district saves on hiring trainers, paying teachers to attend conferences, hiring consultants, paying for substitutes, paying for travel, and so forth.

Teachers will learn more effectively and information will be accessed, disseminated, and used on an as-needed basis by teachers, parents, students, and administrators. The individualized use/learning of information and access to the resources on a self-paced basis by all cannot be attained without the use of these technologies.

Collaboratories

Williams (1991) identifies collaboratories as systems that predominantly serve scientists and researchers. Collaboratories

> *support people-to-people cooperation and collaboration, access to expensive and remote equipment and instruments, as well as links with large databases. (p. 92)*

The emphasis from the original plan for collaboratories developed by the National Science Foundation in 1988 has been to provide more and better opportunities for these individuals to work together and share information, thus increasing their productivity and giving them access to resources that otherwise would be unavailable to them. But elementary and secondary education can enjoy these same benefits.

The emphasis from the original plan for collaboratories has been to provide more and better opportunities for these individuals to work together and share information.

The vast amount of data and information available, while greatly increasing the resources we can use to solve problems, belies the fact that individual researchers, or even groups of researchers, must analyze and make sense of it all (Gomez, 1994). In this environment, students emerge as logical sources for assistance. Not only will they benefit by being able to actively participate in the scientific inquiry process, using real data, but they represent a whole community that can help turn raw data into useful information, providing relevant, live, interactive learning environments where they participate in creating new knowledge by electronically interacting with researchers, scientists, and research agencies as well as other teachers and classrooms.

It is important to note the information-democratizing potential of collaboratories. One characteristic of today's libraries and schools generally is that they are very much "feed-forward" enterprises. Scientists and other professionals create the information and others, like teachers, students, and the populace at large, consume it. In our conception of a collaboratory, this will change. For example, scientists, the traditional information creators, will be in much closer electronic contact with students and teachers, the traditional information consumers. The result of the close encounter between information creators and information consumers could be a fundamental modification in roles. The consumers, in this case students, may become more active participants and migrate into the role of information producers themselves, creating the kind of challenging learning that school reform demands.

Today's teachers and students represent an untapped resource to produce new information in the larger community of learners. From the particular perspective of school communities, this technology could bring a change in the "psychology" of school funding and the perceived value of schools. Today, schools are viewed as a very long-term investment. New representations that embody the experience and advice of others, and new human interfaces that take advantage of these representations, could engage information consumers in meaningful and shareable information production. Students, teachers, and schools could thus become value-added information producers.

Today's teachers and students represent an untapped resource to produce new information in the larger community of learners.

Regional Information Infrastructures and Rural Development

Rural development will occur through the strategic application of telecommunications initiatives for both business and education. Rural communities can draw business to the area by ensuring a strong local telecommunications infrastructure, including sophisticated services such as alternate routing of 800 number calls and improved data transmission services (Parker et al., 1991).

Regional approaches to providing telecommunications services also will emerge. For instance, as Parker et al. (1991) note:

> *(N)ew partnerships for using telecommunications—among several rural communities or among segments of a single rural community—have a large, untapped potential. Partnerships help achieve economies of scale that are otherwise unattainable, creating new "win-win" situations for everyone. Towns can be allied with each other and reap the benefits enjoyed by much larger towns and cities—lower costs, access to diverse information sources, a greater differentiation of products and services. The participants all gain new telecommunication capacities . . . . (p. 9)*

A key component of making this strategy work, however, is the active role of state development programs:

> *If state development programs are truly going to reach the most needy and less developed regions, they must undertake a more aggressive outreach program to inform communities about state aid programs and help them develop local leadership. (Parker, 1991)*

Telecommunications and information technologies, when viewed from a regional perspective, are closely linked to development, whether local or regional. They do not exist in a vacuum. By their very nature, they presume connectivity and communication and reach out to a wide audience—and this audience is made up of businesses and schools as well as individuals.

Communities must look upon their efforts to enhance their telecommunications capabilities and improve their access to such services as development activities. Schools that are able to integrate technology will produce students who are well versed in its applications. Students who possess this knowledge will help local businesses remain competitive. Profitable businesses, in turn, contribute to the well-being of the community. Development, in this sense, means development of both the community and of the individuals within that community.

Conclusions

Supporting traditional education or the status quo will not be sufficient to meet the higher standards we are expecting from students. In order to help students meet the standards that are being called for, schools and districts will find that it is imperative for systemic school reform to occur. Systemic school reform means taking into account and addressing all aspects of the educational system. It is concerned with school finance, time and learning, the integration of services, student and teacher safety, the individualization of instruction and institutionalization of collaborative learning activities, and the application of higher-order thinking skills.

It will be difficult, if not impossible, to meet the new challenging state and national standards through the current educational system. The new standards build off of roles for teachers and students that differ significantly from traditional practice in many cases. They encourage the teacher to act as a facilitator in the classroom, guiding student learning rather than prescribing it. The students, in turn, "construct" their own knowledge, based on information and data they manipulate themselves. No longer will they sit passively and memorize.

Technology emerges as a powerful tool to help implement systemic reform and enhance instruction in this new, more challenging learning environment. The learning environment will be one in which students do more that just sit passively at their desks listening to a teacher lecture for the majority of the time. We are advocating, instead, for a community of learners in which the students and the teacher interact with other learners, resources and information from outside the classroom as well as from within it. Students and teachers will become part of an environment in which they will participate actively as individuals and as part of groups to address relevant issues and create a perspective that is uniquely their own. Along the way, they will be able to access almost unlimited resources and information that they can analyze and add to their own knowledge. Technologies become the tools that allow them to become active members of such communities.

We are advocating for a community of learners in which the students and the teacher interact with other learners, resources and information from outside the classroom as well as from within it.

The collaborative learning environments being called for through these efforts will enhance the role of the teacher rather than diminish it. They also build upon the natural human tendency to work in groups rather than in isolation. Technology contributes to this collaborative environment through the access it provides to rich information resources, as well as other individuals and groups, that are most easily navigated when it is possible to share and analyze the ideas they suggest with peers and teachers.

Technology can help teachers and their students successfully play the new roles that will be required of them. In the case of teachers, it means they will be able to report and chart progress on a more individualized basis, even as the learning experiences themselves become more collaborative. They can take advantage of resources that are available to them from across the globe or across the street and create different learning environments without ever leaving the classroom. In addition, professional development activities and courses will be accessible to them electronically. Students, on the other hand, will be able to access a vast array of material, consult with experts and peers through networking capability, and engage in the analysis of real-world problems and questions. This process means using time in the classroom to concentrate on broad issues rather than on discrete facts, suggesting that the school day itself as well as class periods need to be redefined.

The teachers will become facilitators and will receive the amount and kind of professional development they need to take on this new role; the students will become active learners who use interactive technologies that provide them with curriculum that is always up to date and information that is appropriate to their needs. In such an environment, the rate of learning is highly individualized and the content can be manipulated either by the students or the teacher to fit different levels of understanding. In any case, the information is always relevant and creates a motivation for learning that becomes inherent in the school and for the students and the teachers. The result is that the meaning of schooling and learning reaches beyond the walls of the school building; the library, in turn, includes more than just the textual materials on the shelves. This atmosphere resembles the kind that is found in many professions where learning is valued and ongoing. These are the characteristics of a learning environment that will help our students develop an attitude of lifelong learning that they will take with themselves when they leave school. They will be prepared for what the world has to offer.

We must let the curriculum guide the investment in technology and not let technology dictate the curriculum.

However, the achievement of high standards applying technology, along with these new approaches to teaching and learning, requires more than simply identifying what the standards are. How schools prepare to implement learning environments that encourage inquiry and take into account different levels of understanding needs to be planned. We believe that part of this planning involves making technologies available to teachers and students that will enable them to create these learning environments. This planning must be systemic; it must be part of federal, state, and local efforts to help students and teachers meet the challenging new standards.

Federal, state, and local policymakers must lead the way by providing the necessary resources, although there are many questions they will have to ask themselves in doing so. For instance, equity and funding are examples of issues that are usually considered to be confounding ones for education. However, high standards will affect all students. All students will need appropriate resources and equal opportunities to reach those standards. It is therefore the responsibility of government, at every level, to make it possible for traditionally underrepresented populations to afford and have access to technology that can help them achieve those standards. Government policy must lead the way—through regulations and policies that minimize rather than exacerbate existing inequities—in making these resources available where they are most needed. Only in this way can their benefits reach all students.

Another major area of consideration is the questions schools, districts, and states must ask themselves about curriculum before they think about integrating technology into the schools. They must let the curriculum guide the investment in technology and not let technology dictate the curriculum. They must ask how these technologies can achieve curricular aims. They must determine how teachers will use these technologies to help achieve enhanced learning as well as who will pay for training teachers in the use of the technology. Foremost among these questions, they will want to determine what it is they want to achieve with respect to curriculum changes and systemic reform.

In fact, one of the most salient connections may be the one between these areas and the movement at the federal and state levels to develop challenging standards through processes, such as the national education goals, and new legislation such as the Goals 2000: Educate America Act (P.L.103-227). The main point here is that any choices that are made about what kind of technology teachers will be using and how they will use it should be direct outgrowths of the school's or district's curricular goals. Technology should work in the service of those goals. Curriculum is the driver, not technology.

But having the curricular goals in place and the technology chosen is not the entire answer. If teachers are handed a list of these goals and presented with the technology to support them, it is still not a given that they will know what to do with it. All of the work that went into developing goals and creating technology plans must be backed up with training for teachers—not only to help them understand how the technology works and make them comfortable with it, but more important, to help them see how the technology supports the goals of the curriculum and how to use it for this purpose. In addition, when paired with appropriate technology, professional development assists teachers in determining the most useful applications for different technologies.

Outside of direct classroom applications, telecommunications and information technologies could make it possible to address the nonacademic needs of students more efficiently and effectively. Health-care providers and social service agencies could share information with each other and with the school to avoid duplication of services and to serve a child's needs more comprehensively. In addition, security services could also be connected to the network system. Instead of paying for a separate set of services, the safety of teachers and students could be addressed using this one technology. Finally, school, district, and state education budgets would reflect the infusion of technology and the changes in the way the need for direct and indirect services in schools are met.

However, it is indeed the case that technology can be expensive. Schools will need to develop a long-range investment plan that allows them to provide training and cover maintenance and administrative costs.

Among these costs, professional development in the use and application of technology is one that is particularly substantial. But it is an essential cost. Addressing these needs means that the technology will prove to be a worthwhile investment because it will pay off in a focused approach to teaching—with all staff working towards the same goals. Otherwise, the school or district will find that all they managed to do was spend a lot of money on a lot of equipment without gaining anything from it in return.

Schools will need to develop a long-range investment plan that allows them to provide training and cover maintenance and administrative costs.

It is impossible, though, for many schools and districts to afford what they need—even if they know what they need—without help. That help can come in a number of different forms, either through assistance available from federal or state sources, or by combining resources and purchasing power with other schools, districts, and even states. It is this latter idea, which can be described as regionality, that increases the potential of what can be done with technology. It means greater purchasing power and more leverage when negotiating with vendors. It means less duplication of effort between schools, districts, and states. It means more coordination between these entities, making it possible for teachers and students to learn from and with teachers and students in other areas because the equipment that they use will be compatible, opening up a host of opportunities for collaboration. It means that all of these entities can make their dollars go further and buy more than they would be able to if they were to pursue these goals on an individual basis.

In addition, by pairing schools, districts, and states with private industry or other resources, such as the national energy laboratories, the power of networking can be made available, but without the high costs that would normally be associated with it. Neither states, districts, nor schools would have to find ways to pay for a server; rather, teachers and students would hook into a server housed at one of the laboratories. These sorts of connections could also provide assistance in training, implementation, and so forth. In fact, partnerships of this nature are already in existence or are being created at sites throughout the country.

The message here is one of cooperation—in funding, planning, and implementation. Faculty and administrators must work together to create a coherent curriculum. They must also make sure that the connection between the curriculum and the technology is a strong one and that all necessary training is available. Public and private industry must team with states, districts, and schools to help provide the equipment and other assistance that might otherwise be inaccessible or prohibitive in cost. States, districts, and schools must form partnerships that will increase their purchasing power and clout. An added benefit here is that teachers and students in totally different locations will be able to work with each other and with experts in many different fields across long distances. And it is at this point that the process comes full circle. It is these advantages that will be impossible to reap unless curriculum planning takes center stage.

Policy Recommendations

Federal Level

It is our recommendation that, at the federal level of government, specific legislation, such as S. 1040 (Technology for Education Act of 1994) and H.R. 6 (Elementary and Secondary Education Act) (ESEA) be enacted so that the U.S. Department of Education (DOE) can assume a leadership role in planning for and implementing the National Information Infrastructure. The federal government has recognized the importance of promoting high standards in K-12 education through law such as Goals 2000: Educate America Act (P.L.103-227) and legislation such as ESEA. The fact that these high standards can be supported through appropriate applications of technology therefore demands careful coordination between federally designated technology planners and educators, such as those called for in S. 1040 and H.R. 6. The groups that will be charged with planning for technology need to map the exact steps that need to be taken to achieve coordination and foster the attainment of higher standards. One way to do so would be to test-run a full-blown version of the NII at selected representative schools. The National Aeronautics and Space Administration (NASA), through various grant initiatives, has already begun efforts to develop the types of applications that will be available to schools over the NII. Although these activities should result in compilations of information that meet the curricular requirements of schools, the federal government will have to determine how this kind of information will be combined with all of the other resources that the NII will contain. Another approach would be to ascertain how to go ensure that all schools have access to other technologies such as satellite and cable. In this case, it might do well to partner with agencies such as the Public Broadcasting Service (PBS). To get to this point, however, technical experts and educators must specifically define how the connections will be made. Teachers and students can then provide these planners with feedback as to how well those connections work.

The information tools and resources must be integrated into an equitable, effective process for school improvement, and issues of access, training, and technical assistance must be addressed.

We know that information and knowledge tools are useful in many more ways than through applications in science and mathematics classrooms because they have an impact on the very way we communicate, learn, and work. Yet, as our education system wrestles with the issues surrounding restructuring schools, many educators are not informed about how connectivity to the NII or evolving telecommunications and information technologies might assist them in addressing such issues. The information tools and resources must be integrated into an equitable, effective process for school improvement, and issues of access, training, and technical assistance must be addressed.

It is important to keep in mind also that standards and curriculum can act as a double-edged sword. While standards can help provide the basis for restructuring schools to help all students reach high levels of achievement, they can also act as a wedge to exacerbate inequities that already exist. In the same way, technology, when applied to the curriculum, can aid students in reaching high standards; but, because of limited funding, it may also further the gap between the "haves" and the "have nots," especially if insufficient emphasis is given to providing access to disadvantaged students and historically underserved areas. Although the NII is promoted as a great equalizing force in education, it has this potential to exacerbate existing inequities.

State Level

States responsibilities in this arena will focus on coordinating the development of challenging standards with major federal initiatives such as Goals 2000, ESEA, and the School-to-Work Opportunities Act of 1993 (H.R. 2884; S. 1361), among others. Our recommendation for states then, is that, as they develop standards, they devote considerable attention to the task of addressing the kind and the amount of resources they will need to provide in the areas of professional development and technical assistance. The states will also need to connect their goals for what students should know and be able to do with the capabilities of telecommunications and information technologies. One of the ways they can go about completing this particular task would be to outline what it is each of the different technologies can do, accompanied by suggestions as to what kinds of curricular goals might be met by such applications. When these tasks are completed, the state department of education could then proceed to design a statewide system that is based on equity and the achievement of high standards and that will electronically connect schools to telecommunications and information resources as well as to each other. The alternative would be to provide local schools and districts with their findings in order to encourage planning and implementation activities for technology that are based on high standards and learning goals. At the same time, they can compile information and make recommendations about issues such as technical standards, system maintenance, and financing. Either way, the responsibility of the state would be to gather and analyze information that can help guide technology applications that are supportive of student learning. The goal is to identify teaching strategies and technologies that, when implemented, will lead to noticeable gains in student achievement levels.

Professional development will have an important role in these activities. Both P.L. 103-227 and H.R. 6 recognize that it is crucial that sufficient training and support be provided to teachers, especially as they are asked to become proficient in teaching strategies that focus on inquiry-based methods of learning and the use of technology in implementing them. Since it is quite possible that teachers might have little to no familiarity with either these types of teaching strategies, or with telecommunications and information technologies, this need is all the more pressing.

> ***The states will also need to connect their goals for what students should know and be able to do with the capabilities of telecommunications and information technologies.***

Increasing the type, the quality, and the number of professional development opportunities in the content areas, and enhancing these opportunities by applying telecommunications and information technologies will make it easier for teachers to begin to experiment with new approaches to instruction. Without the opportunity for focused, sustained professional development addressing standards, research on learning, and strategies for change in the classroom, reform efforts on any level will be very difficult to achieve. It is the position of this paper that if systemic school reform in this country is to succeed, it will only do so with the application of telecommunications and information technologies at the classroom level with a simultaneous focus on sustained professional development for teachers.

States can assure the availability of these resources by enacting legislation that provides for leadership on the part of the state, technical support, and planning grants. They can also set state regulations that will result in affordable and universal access to telecommunications and information technologies for all students in all schools in order to support them in meeting the challenging new state content standards.

District Level

Districts will have to engage in the same activities that we are recommending for the states. It is our recommendation that districts and schools form committees of teachers, administrators, parents—and perhaps even students—and charge them with the task of assessing the curricular needs of the district or school, especially in light of higher state and local standards. What these committees are expected to accomplish should be explicitly stated and the responses they develop should, in turn, carry the weight of authority and contain specific directions for implementation.

One of their tasks will be to determine how best to utilize the resources available to them through federal and state agencies. Districts and schools may decide that they will start with low-tech systems and slowly introduce their staff and students to the capabilities of technology. On the other hand, they could choose to immediately implement high-tech systems that perform multiple functions such as Internet access and graphics programs. In either case, we encourage districts and schools to make sure that any technology choice promotes the curricular goals they espouse and that it appropriately matches a technology's capabilities to the tasks for which it will be used. Both low-end and high-end technologies can be applied to the types of inquiry-based methods of instruction called for in systemic reform.

Districts will have to take advantage of the professional development resources available to them from the state and adapt them to their own particular needs. They can also build upon the content area expertise held by their teachers and administrators, buttressed by assistance from or consultation with curriculum experts. It will also be the district's responsibility to create a plan for the implementation and application of telecommunications and information technologies and the use of national and state databases, basing their choices on their curriculum goals and their needs and supported by local and state resources.

Funding

At the end of the paper, we make the case that alternative forms of funding represent one of the most powerful mechanisms available for bringing well-developed technology systems into the schools. Technology is expensive enough that many states, districts, or schools, working alone, would have difficulty in generating the amounts of money necessary to put into place high-speed networked systems. We recommend that regional consortia be considered as a way in which technology can be financed. Regional consortia can help a state's, district's, or school's dollar go further. Partnerships such as regional consortia can cut down on the duplication of effort that might occur when states and districts implement technology systems on their own.

We recommend that states, districts, and schools actively promote the creation of public/private ventures by giving specific personnel the responsibility to pursue this activity. These individuals should have the authority to draw up agreements between various partners, with the understanding that these plans will be submitted for approval to state boards of education, school boards, or local school councils, as appropriate. In this way, an expertise in this area is located in one place and a momentum for using these arrangements will begin to emerge.

Of course, what actual implementation of these recommendations looks like and the extent to which the assumptions will affect decisions at the federal, state, and local levels will vary. For instance, some states may be quite far along in the process of using new teaching strategies and technology applications to help meet challenging state standards. Others may have yet to embark on such journeys. Our purpose in presenting these recommendations is simply to make the case that these issues, taken together, represent a framework we feel is useful for thinking about what the potentials—as well as the realities—are for the application of technology to education.

Endnotes

1. The National Board for Professional Teaching Standards is setting advanced standards in more than 30 certificate fields. The certificates to be offered are structured around two dimensions—the developmental level of the student(s) and the subject(s) being taught.

2. In Appendix E you will find the objectives stated under each goal.

3. There is a list of the eight groups developing the national standards in each of the content areas, as well as their addresses and phone numbers, in Appendix G.

4. The entire Executive Summary can be found in Appendix A. The Internet address to obtain the entire document can be found there as well.

5. An example of an email message from a student trying to identify ways in which his school could connect to the Internet is included in Appendix B.

6. The table showing the connections between these reforms and technologies can be found in Appendix H.

7. The full text is in Appendix F.

8. The names and numbers of some of these relevant bills can be found in Appendix C.

9. A side-by-side comparison of these sections from each of the bills can be found in Appendix D.

10. In Appendix K, two tables developed by Far West Laboratory highlight the different emphases advocated in technology plans and policy documents by (1) selected states, and (2) various professional organizations and legislative initiatives.

11. Referenced by David (1993).

12. Adapted from David (1993).

13. Funding options will be explored in a later section.

14. It might be argued that these standards ought to be set at a federal or regional level. It is our belief that the adoption of these types of technical standards has the greatest chance of being legislated at the state level. Hence, we advocate creating a state education market of sufficient magnitude to influence software development. If several states adopt the same standards, so much the better.

15. In a telephone conversation with Professor Beck, a contrast was made between current computer-based modes with the applications that will be available in the future through the use of imaging technologies. He pointed out how the software associated with that technique will enable students to react, respond, and analyze material along many parameters and using many different strategies. The implication is that it will be possible to develop software that can be adapted to the needs, interest, and abilities of individual students. [NCREL Memorandum (1993)].

16. The terms *hypermedia*, *multimedia*, and *integrated media* refer to the nonlinear integration of information from a variety of media (text, audio, video, or computer graphics) controlled by a computer program.an integrated media format, a computer screen displaying text or graphics might look very much like a page of a book. However, unlike ordinary print material, which is organized in a linear order, electronic links or "buttons" in the program allow the user immediate and random access an electronic pointer to any reference and selecting it (by clicking on the mouse) could produce, on the screen, both the source and an abstract of the work. When the computer is connected to a videodisc player (or has access to other sources of video or audio), electronic "buttons" on the computer screen provide access to information in other formats. ***For example, a paragraph describing characteristics of the redesigned classroom might contain links to instructional activities or to audio segments from interviews with teachers who are in the process of redesigning their approaches to instruction.*** [Barron & Goldman (1993), pp. 70-71]

17. NCTM, in addition to releasing curriculum and evaluation standards, has also published professional standards for the teaching of mathematics.

18. A one-page summary of the partnership can be found in Appendix I.

19. Horowitz's (1993) five-part agenda can be found in Appendix J.

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AGENDA FOR ACTION
THE NATIONAL INFORMATION INFRASTRUCTURE

EXECUTIVE SUMMARY

All Americans have a stake in the construction of an advanced National Information Infrastructure (NII), a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips. Development of the NII can help unleash an information revolution that will change forever the way people live, work, and interact with each other:

- People could live almost anywhere they wanted, without foregoing opportunities for useful and fulfilling employment, by "telecommuting" to their offices through an electronic highway;
- The best schools, teachers, and courses would be available to all students, without regard to geography, distance, resources, or disability;
- Services that improve America's health care system and respond to other important social needs could be available on-line, without waiting in line, when and where you needed them.

Private sector firms are already developing and deploying that infrastructure today. Nevertheless, there remain essential roles for government in this process. Carefully crafted government action will complement and enhance the efforts of the private sector and assure the growth of an information infrastructure available to all Americans at reasonable cost. In developing our policy initiatives in this area, the Administration will work in close partnership with business, labor, academia, the public, Congress, and state and local government. Our efforts will be guided by the following principles and objectives:

- Promote private sector investment, through appropriate tax and regulatory policies.
- Extend the "universal service" concept to ensure that information resources are available to all at affordable prices. Because information means empowerment--and employment--the government has a duty to ensure that all Americans have access to the resources and job creation potential of the Information Age.
- Act as a catalyst to promote technological innovation and new applications. Commit important government research programs and grants to help the private sector develop and demonstrate technologies needed for the NII, and develop the applications and services that will maximize its value to users.
- Promote seamless, interactive, user-driven operation of the NII. As the NII evolves into a "network of networks," government will ensure that users can transfer information across networks easily and efficiently. To increase the likelihood that the NII will be both interactive and, to a large extent, user-driven, government must reform regulations and policies that may inadvertently hamper the development of interactive applications.
- Ensure information security and network reliability. The NII must be trust- worthy and secure, protecting the privacy of its users. Government action will also ensure that the overall system remains reliable, quickly repairable in the event of a failure and, perhaps most importantly, easy to use.
- Improve management of the radio frequency spectrum, an increasingly critical resource.

- Protect intellectual property rights. The Administration will investigate how to strengthen domestic copyright laws and international intellectual property treaties to prevent piracy and to protect the integrity of intellectual property.

- Coordinate with other levels of government and with other nations. Because information crosses state, regional, and national boundaries, coordination is critical to avoid needless obstacles and prevent unfair policies that handicap U.S. industry.

- Provide access to government information and improve government procurement. The Administration will seek to ensure that Federal agencies, in concert with state and local governments, use the NII to expand the information available to the public, ensuring that the immense reservoir of government information is available to the public easily and equitably. Additionally, Federal procurement policies for telecommunications and information services and equipment will be designed to promote important technical developments for the NII and to provide attractive incentives for the private sector to contribute to NII development.

The time for action is now. Every day brings news of change: new technologies, like hand-held computerized assistants; new ventures and mergers combining businesses that not long ago seemed discrete and insular; new legal decisions that challenge the separation of computer, cable, and telephone companies. These changes promise substantial benefits for the American people, but only if government understands fully their implications and begins working with the private sector and other interested parties to shape the evolution of the communications infrastructure.

The benefits of the NII for the nation are immense. An advanced information infrastructure will enable U.S. firms to compete and win in the global economy, generating good jobs for the American people and economic growth for the nation. As importantly, the NII can transform the lives of the American people--ameliorating the constraints of geography, disability, and economic status--giving all Americans a fair opportunity to go as far as their talents and ambitions will take them.

HOW TO GET THE DOCUMENT

The package is available in ASCII format from a variety of electronic sources including the following:

1. *Internet.* The package is available in ASCII format through both FTP and Gopher. The name of the file is "niiagenda.asc". Access information and directories are described below.

   FTP:
   Address:ftp.ntia.doc.gov
   Login as "anonymous". Use your email address or guest as the password. Change directory to "pub".
   Address:enh.nist.gov
   Login as "anonymous" using "guest" as the password.
   Address:isdres.er.usgs.gov
   Login as "anonymous". Use your email address or "guest" as the password. Change directory to npr.

   The package also may be present in a self extracting compressed file named "niiagend.exe". Remember to issue the binary command before "getting" the compressed file.

Gopher (server/client):

Telnet to:gopher.nist.gov
Login as "gopher". Choose the menu item "DOC Documents". Choose "niiagenda.asc".
Gopher to:ace.esusda.gov, port 70

Select:

6. Americans Communicating Electronically
3. National Technology Information
1. National Information Infrastructure Agenda

Email

Send a message to nii@ace.esusda.gov

You will not have to place anything in the body of the message and you will be sent the entire document.

Source:Internet

Date:Mon, 17 Jan 94 01:08:11 -0500 **Appendix B**

From:ch660@cleveland.Freenet.Edu (Jeremy Seitz)

Subject:Schools on Internet

I am a student at Westlake High school (outside of Cleveland OH). Several students are currently looking into starting up a school BBS for both faculty and students. I have posted like crazy recently, getting bits of info about various topics, such as what system to use and how to get Internet access. EdPOL is the only discussion I have seen referring to schools getting onto Internet or the like. I was wondering if you could help us in any way on how to set up our BBS.

Our first problems are going to be selling the idea to the administration and getting money for the project. The students I am working with understand the incredible potential for such a system, but we do not run the school. If you know of anyone/group that could help us please refer us to them.

Source:Stout, Connie (Ed.) (1994). *EdPOL-D, 1* (2).

FEDERAL LEGISLATION

Number	Title
H.R.6	Elementary and Secondary Education Act (ESEA)
H.R.89	Technology Education Assistance Act of 1993
H.R.820	National Competitiveness Act of 1994
P.L.103-227	Goals 2000: Educate America Act
H.R.2268	Establishment of a National Telecommunications System
H.R.2518	Appropriations
H.R.2639	Telecommunications Infrastructure and Facilities Assistance Act of 1993
H.R.2728	Technology Education Assistance Act of 1993
S.1040	Technology for Education Act of 1994
H.R.2884/S.1361	School-to-Work Opportunities Act of 1993
H.R.3626	Antitrust Reform Act of 1993; Communications Reform Act of 1993
H.R.3636	National Communications Competition and Information Infrastructure Act of 1993

Source:RPIC/NCREL

H.R.6	P.L.103-227
SEC.2216.NATIONAL LONG-RANGE PLAN.	(b) National Long-Range Technology Plan.--
(a) In General.--	(1) In general.--
(1) The Secretary shall develop and publish by September 30, 1995, and update when appropriate, a national long-range plan to carry out the purposes of this subpart.	The Secretary shall develop and publish within 12 months of the date of enactment of this Act, and update when the Secretary determines appropriate, a national long-range plan that supports the overall national technology policy and carries out the purposes of this part.
(2) The Secretary shall--	(2) Plan requirements.--The Secretary shall--
(A) develop the plan in consultation with other Federal agencies, State and local education practitioners and policy-makers, experts in technology and the educational applications of technology, and providers of technology services and products;	(A) develop the national long-range plan in consultation with other Federal departments or agencies, State and local education practitioners and policymakers, experts in technology and the educational applications of technology, representatives of a distance learning consortia, representatives of telecommunications partnerships receiving assistance under the Star Schools Program Assistance Act, and providers of technology services and products;
(B) transmit the plan to the President and to the appropriate committees of the Congress; and	(B) transmit such plan to the President and to the appropriate committees of the Congress; and
(C) publish the plan in a form that is readily accessible to the public.	(C) publish such plan in a form that is readily accessible to the public.
(b) Contents of the Plan.--The national long-range plan shall describe the Secretary's activities to promote the purposes of this subpart, including--	(3) Contents of the plan.--The national long-range plan shall describe the Secretary's activities to promote the purpose of this part, including--
(1) how the Secretary will encourage the effective use of technology to provide all students the opportunity to achieve to challenging State standards, especially through programs administered by the Department;	(A) how the Secretary will encourage the effective use of technology to provide all students the opportunity to achieve challenging State content standards and challenging State student performance standards, especially through programs administered by the Department of Education;
(2) joint activities with other Federal agencies, such as the National Endowment for the Humanities, the National Endowment for the Arts, the Na-	(B) joint activities in support of the overall national technology policy with other Federal departments or agencies, such as the Office of Science

tional Aeronautics and Space Administration, the National Science Foundation, and the Departments of Commerce, Energy, Health and Human Services, and Labor, to promote the use of technology in education, and training and lifelong learning, including plans for the educational uses of a national information infrastructure, and to ensure that the policies and programs of such agencies facilitate the use of technology for educational purposes to the extent feasible.	and Technology, the National Endowment for the Humanities, the National Endowment for the Arts, the National Aeronautics and Space Administration, the National Science Foundation, and the Departments of Commerce, Energy, Health and Human Services, and Labor--
	(i) to promote the use of technology in education, and training and lifelong learning, including plans for the educational uses of a national information infrastructure; and
	(ii) to ensure that the policies and programs of such departments or agencies facilitate the use of technology for educational purposes, to the extent feasible;
(3) how the Secretary will work with educators, State and local educational agencies, and appropriate representatives of the private sector to facilitate the effective use of technology in education;	(C) how the Secretary will work with educators, State and local educational agencies, and appropriate representatives of the private sector to facilitate the effective use of technology in education;
(4) how the Secretary will promote--	(D) how the Secretary will promote--
	(i) higher achievement of all students through the integration of technology into the curriculum;
(A) increased access to the benefits of technology for teaching and learning for schools with high concentrations of children from low-income families;	(ii) increased access to the benefits of technology for teaching and learning for schools with high concentrations of children from low-income families;
(B) the use of technology to assist in the implementation of State systemic reform strategies;	(iii) the use of technology to assist in the implementation of State systemic reform strategies;
(C) the application of technological advances to use in education; and	(iv) the application of technological advances to use in education; and
(D) increased opportunities for the professional development of teachers in the use of new technologies;	(v) increased opportunities for the professional development of teachers in the use of new technologies;
(5) how the Secretary will determine, in consultation with appropriate individuals, organizations, and agencies, the feasibility and desirability of establishing guidelines and protocols to facilitate effective use of technology in education; and	(E) how the Secretary will determine, in consultation with appropriate individuals, organizations, industries, and agencies, the feasibility and desirability of establishing guidelines to facilitate an easy exchange of data and effective use of technology in education;

(6) the Secretary's long-range measurable goals and objectives relating to the purposes of this subpart.

(F) how the Secretary will utilize the outcomes of the evaluation undertaken pursuant to section 908 of the Star Schools Program Assistance Act to promote the purposes of this part; and

(G) the Secretary's long-range measurable goals and objectives relating to the purposes of this part.

(c) Assistance.--The Secretary shall provide assistance to the States to enable such States to plan effectively for the use of technology in all schools throughout the State in accordance with the purpose and requirements of section 316.

In addition, activities are identified for the uses of funds:

SEC.2217.FEDERAL LEADERSHIP.

(a) Program Authorized.--

(1) In order to provide Federal leadership in promoting the use of technology in education, the Secretary, in consultation with the National Science Foundation, the Department of Commerce, and other appropriate Federal agencies, may carry out activities designed to achieve the purposes of this subpart directly or by awarding grants (pursuant to a peer review process) to, or entering into contracts with, State educational agencies, local educational agencies, institutions of higher education, or other public and private nonprofit or for-profit agencies and organizations.

(2) For the purpose of carrying out coordinated or joint activities consistent with the purposes of this subpart, the Secretary may accept funds from, and transfer funds to, other Federal agencies.

(d) Uses of Funds.--The Secretary may use funds appropriated under this subpart for activities designed to carry out the purposes of this subpart, and to meet the goals and objectives of the national long-range plan under section 216, including--

SEC.222.FEDERAL LEADERSHIP.

(a) Activities Authorized--

(1) In general.--In order to provide Federal leadership that promotes higher student achievement through the use of technology in education and to achieve the purposes of this part, the Secretary, in consultation with the Office of Science and Technology Policy, the National Science Foundation, the Department of Commerce, the Department of Energy, the National Aeronautics and Space Administration, and other appropriate Federal departments or agencies, may carry out activities designed to achieve the purposes of this part.

(2) Transfer of funds.--For the purpose of carrying out coordinated or joint activities to achieve the purposes of this part, the Secretary may accept funds from, and transfer funds to, other Federal departments or agencies.

SEC.224.USES OF FUNDS.

(a) In General.--The Secretary shall use funds appropriated pursuant to the authority of section 231(d) for activities designed to carry out the purpose of this part, including--

(1) planning grants to State and local education agencies, to enable such entities to examine and develop strategies for the effective use of technology to help achieve the objectives of the *Goals 2000: Educate America Act* and the *School-to-Work Opportunities Act of 1993*;	
(2) development grants to technical assistance providers, to enable them to improve substantially the services they offer to educators on the educational uses of technology, including professional development;	(1) providing assistance to technical assistance providers to enable such providers to improve substantially the services such providers offer to educators regarding the educational uses of technology, including professional development;
(3) consulting with representatives of industry, elementary and secondary education, higher education, and appropriate experts in technology and its educational applications in carrying out activities under this subpart;	(2) consulting with representatives of industry, elementary and secondary education, higher education, and appropriate experts in technology and the educational applications of technology, in carrying out the activities assisted under this part;
(4) research on, and the development of, guidelines and protocols to facilitate efficient and effective use of technology in education;	(3) research on, and the development of, guidelines to facilitate maximum interoperability, efficiency and easy exchange of data for effective use of technology in education;
(5) research on, and the development of, educational applications of the most advanced and newly emerging technologies;	(4) research on, and the development of, educational applications of the most advanced and newly emerging technologies;
(6) the development, demonstration, and evaluation of applications of existing technology in preschool education, elementary and secondary education, training and lifelong learning, and professional development of educational personnel;	(5) the development, demonstration, and evaluation of applications of existing technology in preschool education, elementary and secondary education, training and lifelong learning, and professional development of educational personnel;
(7) the development and evaluation of software and other products including television programming, that incorporate advances in technology and help achieve the National Education Goals and challenging State standards;	(6) the development and evaluation of software and other products, including multimedia television programming, that incorporate advances in technology and help achieve the National Education Goals, challenging State content standards and challenging State performance standards;
(8) the development, demonstration, and evaluation of model strategies for preparing teachers and other personnel to use technology effectively to improve teaching and learning;	(7) the development, demonstration, and evaluation of model strategies for preparing teachers and other personnel to use technology effectively to improve teaching and learning;

(9) the development of model programs to demonstrate the educational effectiveness of technology in urban and rural areas and economically-distressed communities;	(8) the development of model programs that demonstrate the educational effectiveness of technology in urban and rural areas and economically distressed communities;
(10) research on, and the evaluation of, the effectiveness and benefits of technology in education;	(9) research on, and the evaluation of, the effectiveness and benefits of technology in education giving priority to research on, and evaluation of, such effectiveness and benefits in elementary and secondary schools;
	(10) a biannual assessment of, and report to the public regarding, the uses of technology in elementary and secondary education throughout the United States upon which private business and Federal, State, and local governments may rely for decisionmaking about the need for, and provision of, appropriate technologies in schools, which assessment and report shall use, to the extent possible, existing information and resources;
(11) conferences on, and dissemination of information about, the uses of technology in education;	(11) conferences on, and dissemination of information regarding, the uses of technology in education;
(12) the development of model strategies to promote gender equity concerning access to, and the use of, technology in the classroom; and	(12) the development of model strategies to promote gender equity in the use of technology;
	(13) encouraging collaboration between the Department of Education and other Federal agencies in the development, implementation, evaluation, and funding of applications of technology for education, as appropriate; and
(13) such other activities as the Secretary determines would meet the purposes of this subpart.	(14) such other activities as the Secretary determines will meet the purposes of this part.
	(b) Special Rules.--
	(1) In general.--The Secretary shall carry out the activities described in subsection (a) directly or by grant or contract.
	(2) Grants and contracts.--Each grant or contract under this part shall be awarded--

	(A) on a competitive basis; and (B) pursuant to a peer review process.
	SEC.225.NON-FEDERAL SHARE.
(c) Non-Federal Share.-- (1) Subject to paragraph (2), the Secretary is authorized to require any recipient of a grant or contract under this subpart to share in the cost of its project, which share shall be announced through a notice in the Federal Register and may be in the form of cash or in-kind contributions, fairly valued.	(a) In General.--Subject to subsections (b) and (c), the Secretary may require any recipient of a grant or contract under this part to share in the cost of the activities assisted under such grant or contract, which non-Federal share shall be announced through a notice in the Federal Register and may be in the form of cash or in-kind contributions, fairly valued.
(2) The Secretary may increase the non-Federal share required of such recipient after the first year of the recipient's project, except that such share may not exceed 50 percent at any time during the recipient's project.	(b) Increase.--The Secretary may increase the non-Federal share that is required of a recipient of a grant or contract under this part after the first year such recipient receives funds under such grant or contract.
	(c) Maximum.--The non-Federal share required under this section shall not exceed 50 percent of the cost of the activities assisted pursuant to a grant or contract under this part.

Source:Side-by-side comparison created by RPIC/NCREL from *H.R. 6* (incorporates *H.R.2728*) and *H.R.1804* (incorporates *S.1040*).

GOALS 2000: EDUCATE AMERICA ACT
(P.L.103-227)

TITLE I: NATIONAL EDUCATION GOALS

GOAL 1 *SCHOOL READINESS*

By the year 2000, all children in America will start school ready to learn.

Objectives

- All children will have access to high-quality and developmentally appropriate preschool programs that help prepare children for school.

- All disadvantaged and disabled children will have access to high quality and developmentally appropriate preschool programs that help prepare children for school.

- Children will receive the nutrition, physical activity experiences, and health care needed to arrive at school with healthy minds and bodies, and to maintain the mental alertness necessary to be prepared to learn, and the number of low-birthweight babies will be significantly reduced through enhanced prenatal health systems.

GOAL 2 *SCHOOL COMPLETION*

By the year 2000, the high school graduation rate will increase to at least 90 percent.

Objectives

- The Nation must dramatically reduce its dropout rate, and 75 percent of those students who do drop out will successfully complete a high school degree or its equivalent.

- The gap in high school graduation rates between American students from minority backgrounds and their non-minority counterparts will be eliminated.

GOAL 3 *STUDENT ACHIEVEMENT AND CITIZENSHIP*

By the year 2000, all students will leave grades four, eight, and twelve having demonstrated competency over challenging subject matter including English, mathematics, science, foreign languages, civics and government, economics, arts, history, and geography, and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our Nation's modern economy.

Objectives

- The academic performance of all students at the elementary and secondary level will increase significantly in every quartile, and the distribution of minority students in each quartile will more closely reflect the student population as a whole.

- The percentage of all students who demonstrate the ability to reason, solve problems, apply knowledge, and write and communicate effectively will increase substantially.

- All students will be involved in activities that promote and demonstrate good citizenship, good health, community service, and personal responsibility.

- All students will have access to physical education and health education to ensure they are healthy and fit.

- The percentage of all students who are competent in more than one language will substantially increase.

- All students will be knowledgeable about the diverse cultural heritage of this Nation and about the world community.

GOAL 4 *TEACHER EDUCATION AND PROFESSIONAL DEVELOPMENT*

By the year 2000, the Nation's teaching force will have access to programs for the continued improvement of their professional skills and the opportunity to acquire the knowledge and skills needed to instruct and prepare all American students for the next century.

Objectives

- All teachers will have access to preservice teacher education and continuing professional development activities that will provide such teachers with the knowledge and skills needed to teach to an increasingly diverse student population with a variety of educational, social, and health needs.

- All teachers will have continuing opportunities to acquire additional knowledge and skills needed to teach challenging subject matter and to use emerging new methods, forms of assessment, and technologies.

- States and school districts will create integrated strategies to attract, recruit, prepare, retrain, and support the continued professional development of teachers, administrators, and other educators, so that there is a highly talented work force of professional development educators to teach challenging subject matter.

- Partnerships will be established, whenever possible, among local educational agencies, institutions of higher education, parents, and local labor, business, and professional associations to provide and support programs for the professional development of educators.

GOAL 5 *MATHEMATICS AND SCIENCE*

By the year 2000, U.S. students will be first in the world in mathematics and science achievement.

Objectives

- Math and science education, including the metric system of measurement, will be strengthened throughout the system, especially in the early grades.

- The number of teachers with a substantive background in mathematics and science, including the metric system of measurement, will increase by 50 percent.

- The number of United States undergraduate and graduate students, especially women and minorities, who complete degrees in mathematics, science, and engineering will increase significantly.

GOAL 6 *ADULT LITERACY AND LIFELONG LEARNING*

By the year 2000, every adult American will be literate and will possess the knowledge and skills necessary to compete in a global economy and exercise the rights and responsibilities of citizenship.

Objectives

- Every major American business will be involved in strengthening the connection between education and work.
- All workers will have the opportunity to acquire the knowledge and skills, from basic to highly technical, needed to adapt to emerging new technologies, work methods, and markets through public and private educational, vocational, technical, workplace, or other programs.
- The number of quality programs, including those at libraries, that are designed to serve more effectively the needs of the growing number of part-time and midcareer students will increase substantially.
- The proportion of the qualified students, especially minorities, who enter college, who complete at least two years, and who complete their degree programs will increase substantially.•The proportion of college graduates who demonstrate an advanced ability to think critically, communicate effectively, and solve problems will increase substantially.

GOAL 7 *SAFE, DISCIPLINED, AND ALCOHOL- AND DRUG-FREE SCHOOLS*

By the year 2000, every school in the United States will be free of drugs, violence and the unauthorized presence of firearms and alcohol and will offer a disciplined environment conducive to learning.

Objectives

- Every school will implement a firm and fair policy on use, possession, and distribution of drugs and alcohol.
- Parents, businesses, governmental and community organizations will work together to ensure the rights of students to study in a safe and secure environment that is free of drugs and crime, and that schools are a safe haven for all children.
- Every local educational agency will develop and implement a policy to ensure that all schools are free of violence and the unauthorized presence of weapons.
- Every local educational agency will develop a sequential, comprehensive kindergarten through twelfth grade drug and alcohol prevention education program.
- Drug and alcohol curriculum should be taught as an integral part of sequential, comprehensive health education.
- Community-based teams should be organized to provide students and teachers with needed support.

- Every school should work to eliminate sexual harassment.

GOAL 8 ***PARENTAL PARTICIPATION***

By the year 2000, every school will promote partnerships that will increase parental involvement and participation in promoting the social, emotional, and academic growth of children.

Objectives

- Every state will develop policies to assist local schools and local educational agencies to establish programs for increasing partnerships that respond to the varying needs of parents and the home, including parents of children who are disadvantaged or bilingual, or parents of children with disabilities.
- Every school will actively engage parents and families in a partnership which supports the academic work of children at home and shared educational decisionmaking at school.
- Parents and families will help to ensure that schools are adequately supported and will hold schools and teachers to high standards of accountability.

LIFE IN CLASSROOMS: A SCENARIO

Appendix F

Ms. Cary teaches 10th grade science at a school in Columbus, Ohio. She has arranged for each of her classes to participate in a sequence of study on atmospheric science by utilizing the *Learning through Collaborative Visualization* testbed, which was created through support from the National Science Foundation (NSF). This opportunity has come about as a result of the easily available connections she has to scientists, university researchers, and teachers at public schools involved with these studies at locations throughout the United States. Some background will illustrate how her particular program of study evolved.

Knowing that the 10th grade science curriculum includes a sequence on the study of atmospheric science, Ms. Cary began her preparation by taking part in an interactive teleconference with the original testbed collaborators. These individuals, representing both practitioners and researchers, shared with her their experiences in piloting the program with groups of students similar to those in her classroom. The testbed's connection with the NSF assures her that the program of study conforms to the existing national standards in mathematics and science, as identified by the collaborative mathematics and science education project under the direction of the regional educational laboratories.

After the teleconference, and having accessed the relevant curriculum materials through a single network interface that includes other science and mathematics data bases, Ms. Cary is ready to have her students begin their own course of study. One of the areas that can be covered through the curriculum involves the short-term and long-term effects on atmospheric conditions after major volcanic eruptions. Although she wants her students to primarily investigate these direct results, she also wants them to attempt to extrapolate how similar, though man-made, conditions might mimic or exacerbate atmospheric events that are due to natural disasters.

Working in groups of four, the students begin their study by searching out several scientists who study phenomena of the type identified. Each group contacts one scientist via email, and by using the interactive video capabilities available at the school, and works with him/her to create a visual representation of the atmospheric changes that occur when a volcano erupts. The scientists also provide the students with raw data and statistics drawn from their own experiments, along with references to journal articles that explain the process in additional detail. With this information in hand, the entire class then participates in a virtual-reality program that recreates the aftermath of such an explosion.

The course of study requires that each class (comprising 24 students per section) produce one report based on the findings of the six individual groups. In order to facilitate the process, Ms. Cary consolidates the raw data into one file for each class, enabling the students to review and manipulate it according to the needs of their particular project. Two groups run statistical programs on the data and create graphs that illustrate the changes in concentrations of certain gases before, during, and after an eruption, and at various distances from the source of the explosion. Two other groups analyze and report on which gases have the most detrimental effect on the atmosphere and why. The remaining two groups project how various lifeforms are affected in the area immediately surrounding the volcano. Although each group works independently for the most part, knowing that there is another group working on the same component of the study enables the students to collaborate with each other along the way, comparing notes on different approaches to the problem they have been asked to solve, much like groups of scientists replicating or confirming the findings of other researchers.

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Prior to starting her students on this sequence of study, Ms. Cary had arranged to let the project unfold in conjunction with the work being done on related topics at two other schools. Accordingly, Ms. Cary informs each of her classes that the students' counterparts at a school in New Orleans, Louisiana, as well as a class of 10th grade students at an inner-city Detroit, Michigan school, are working on projects that investigate the extent to which a volcanic eruption can change weather patterns around the globe. The students at the school in New Orleans access the information they need by tapping into National Weather Service data and satellite images. The students at the Detroit high school apply data and tools from the University Corporation for Atmospheric Research (UCAR) as part of *The Weather Underground* project based at the University of Michigan. Because each of these schools has the capacity to communicate with each other through the National Research and Education Network, the students are able to use the results obtained through each others' studies to more fully understand their own work.

Armed with their graphs, analyses, and projections, Ms. Cary's students prepare to present their findings as part of a teleconference with students from the New Orleans and Detroit schools. Some of the university researchers Ms. Cary interviewed during her initial teleconference also participate, providing feedback to the students regarding their projects and asking questions about their results. Each group of students explains the process they utilized in manipulating the data and highlights the most important elements of their research. Ms. Cary downlinks this information to the other schools and obtains copies of their material for her students.

The end of the project requires Ms. Cary's students to predict the outcome of a conjectured man-made event based on what they have learned about the effects of volcanic eruptions on atmospheric conditions. In this case study approach, Ms. Cary describes a situation in which it is discovered that a factory engaged in the production of defense-related material has discharged a large quantity of material into the air containing chemicals very similar to those found in volcanic ash. An instructional management system makes it possible for Ms. Cary to use one framework to describe the fabricated incident, yet supply each student with a different set of data to evaluate - in this case, the amount and type of gases emitted. She asks the students to develop their responses just as they had in their study of atmospheric conditions after volcanic eruptions. In generating their answers, they run statistical programs to show the changes in concentrations of certain gases before, during, and after the incident and at various distances from the source of the emissions. They analyze and report on which gases have the most detrimental effect on the atmosphere and why. They project how various life-forms are affected in the area immediately surrounding the factory. Their responses make it possible for Ms. Cary to ascertain how well each of them understands the environmental processes involved and whether they can apply suitable research techniques to the problem--all through ordinary applications of a range of technologies that are now common-place in schools throughout the nation.

Source:RPIC/NCREL (Created by Rosemary Bell, 02/93)

ORGANIZATIONS FUNDED BY THE U.S. DEPARTMENT OF EDUCATION FOR THE DEVELOPMENT OF SUBJECT-AREA STANDARDS

- **Curriculum And Evaluation Standards For School Mathematics**
  The National Council of Teachers of Mathematics
  Order Processing
  1906 Association Drive
  Reston, VA 22091
  Item number: 398E1, ISBN 0-87353-273-2

- **Science**
  National Academy of Science
  National Research Council
  2101 Constitution Avenue, NW
  Washington, DC 20418

  Contact:David Florio
  Completion:Winter 1994-95
  Also supported by the National Science Foundation.

- **History**
  National Center for History in the Schools at UCLA
  231 Moore Hall, 405 Hilgard Avenue
  Los Angeles, CA 90024

  Contact:Charlotte Crabtree
  Completion:Winter 1994
  Also supported by the National Foundation for the Humanities.

- **Arts**
  Music Educators National Conference
  1806 Robert Fulton Drive
  Reston, VA 22091

  In coordination with the American Alliance for Theatre and Education, the National Art Education Association, and the National Dance AssociationContact:Peggy Senko
  Completion:Spring 1994
  Also supported by the National Endowment for the Arts and the National Endowment for the Humanities.

- **CIVICS AND GOVERNMENTS**
  Center for Civic Education
  5146 Douglas Fir Road
  Calabasas, CA 91302-1467
  Contact:Charles Quigley
  Completion:Fall 1994
  Also supported by the Pew Charitable Trusts.

- **Geography**
  National Council of Geographic Education
  Geography Standards Project
  1600 M Street, NW
  Washington, DC 20036

  In coordination with the Association of American Geographers, the National Geographic Society, and the American Geographical Society.
  Contact:Anthony DeSouza
  Completion:Fall 1994
  Also supported by the National Endowment for the Humanities

- **English Language Arts**
  The Center for the Study of Reading
  174 Children's Research Center
  51 Gerty Drive
  Champaign, IL 61820

  In coordination with the National Council of Teachers of English and the International Reading Association.
  Contact:Jean Osborn
  Completion:Fall 1995

- **Foreign Language**
  American Council on the Teaching of Foreign Languages, Inc.
  6 Executive Plaza
  Yonkers, NY 10701-6801

  Contact:Jamie Draper
  Completion:Winter 1995
  Also supported by the National Endowment for the Humanities.

U.S. Department Of Education

For general information about content standards development, contact:

Office of Educational Research and Improvement/FIRST Office
U.S. Department of Education
555 New Jersey Avenue, NW
Washington, DC 20208-5524

Table II-2

FEATURES OF EDUCATION REFORM AND SUPPORTIVE TECHNOLOGIES

Features of Education Reform							Potentially Supportive Technology
Heterogeneous Groupings	Performance-Based Assessment	Authentic and Multidisciplinary Tasks	Collaborative Work	Interactive Modes of Instruction	Student Exploration	Teacher as Facilitator	*Given a supportive instructional setting, the following technologies can support various features of reform, as indicated in this chart. It is possible to use the technologies in ways that promote other aspects of reform and many other exemplary products are currently available, but only uses and applications cited in the text are listed here.*
	●	●			●	●	**Electronic Databases** General discussion (pp. 26-27)
		●			●		**Electronic Reference Tools** Data Discman (pp. 26-27) Encyclopedia Britannica (pp. 26-27) The World Almanac and Book of Facts (p. 27)
●	●	●	●	●	●	●	**Hypermedia** Computer Supported Intentional Learning Environments (p. 36) Discover Rochester (p. 37) HyperCard (pp. 36-37)
				●		●	**Intelligent Computer-Assisted Instruction (ICAI)** General discussion (pp. 20-21) Geometry Tutor (p. 21) PIXIE (p. 21)
				●	●	●	**Intelligent Tools** Geometric Supposer (pp. 70-71)
		●	●		●	●	**Microcomputer-Based Labs** General discussion (pp. 26-27, 71-72)
	●	●	●	●	●	●	**Microworlds and Simulations** LOGO (pp. 28-29) LOGOWriter (pp. 28-29) LegoLOGO (pp. 28-29) Catlab (pp. 78, 90) Immigrant 1850 (pp. 61-62, 81) Palenque (p. 31) SimCity (p. 29) SimEarth (p. 29) Voyage of Mimi (pp. 23, 60-61) Where in the World is Carmen Sandiego? (pp. 29, 118)

Table II-2 (concluded)

Features of Education Reform							Potentially Supportive Technology
Heterogeneous Groupings	Performance-Based Assessment	Authentic and Multidisciplinary Tasks	Collaborative Work	Interactive Modes of Instruction	Student Exploration	Teacher as Facilitator	*Given a supportive instructional setting, the following technologies can support various features of reform, as indicated in this chart. It is possible to use the technologies in ways that promote other aspects of reform and many other exemplary products are currently available, but only uses and applications cited in the text are listed here.*
●	●	●	●		●	●	**Multimedia Tools and Approaches** Multimedia Works (p. 38) Point of View (pp. 64-65, 73)
●	●	●	●	●	●	●	**Networks and Related Applications** Discourse System (p. 81) Earth Lab (pp. 69-70, 94, 113) FrEdMail (p. 41) Kids Network (pp. 41, 48, 68-69) Learning Circles (pp. 41, 66-67, 85-87) Learning Network (pp. 41, 66, 85-87) Network 2 (p. 44) SpaceLink (pp. 41, 48)
●				●		●	**Two-way Video/Two-way Audio Distance Learning** General discussion (pp. 40, 43-48) EDNET (pp. 44, 47) TENET (p. 46) WHETS (p. 47)
●	●	●	●		●	●	**Videocameras, VCRs, Editors** MicroMacro Lab (p. 80) VideoPals (p. 42)
		●	●	●	●	●	**Videodisc and CD-ROM** The Adventures of Jasper Woodbury (pp. 30-31) Animal Pathfinders (p. 32) Civil War Interactive (pp. 32, 96-99) The War in the Persian Gulf (pp. 64-65) GTV (pp. 32, 116)
	●	●	●		●	●	**Word Processors/Intelligent Writing Tools** General Discussion (pp. 34-36) Writing Partner (p. 106) TextBrowser (pp. 82-83, 93)

Source: Means, B., Blando, J., Olson, K., Middleton, T., Morocco, C.C., Remz, A.R., & Zorfass, J. (1992). Using technology to support education reform (SRI Project 2882, ED Contract No. RR91172010). Menlo Park, CA: SRI International.

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The Curriculum Network (TCN)

**A project of Far West Laboratory, North Central Regional Educational Laboratory, Pacific Mountain Network and Screen Media Partners*

The Curriculum Network (TCN) is a partnership formed between the public and private sectors in response to the growing technological needs of America's middle and high schools. This partnership is based on the belief that curricular needs must drive the choice of technology, and that technology is an effective tool for delivering curriculum.

TCN will provide middle and high schools with two key educational packages:

- a library of regionalized video-based Curriculum Support Units in the five core subject matter areas; and
- a comprehensive technology planning and leasing program covering all areas of school activities, beginning with equipment needed to deliver the Curriculum Support Units.

What is TCN?

TCN is a unique consortium of public and private entities, including two of the nation's largest publicly supported educational research and development laboratories, a regional public television production and distribution center, and a for-profit consulting firm specializing in the design and launch of large-scale media systems.

The laboratories (Far West and North Central Regional) will, in cooperation with various education organizations, oversee design of the Curriculum Support Units, curriculum evaluation, customizing of content materials to regional education standards, and teacher training activities. Pacific Mountain Network, the public broadcasting agency, will have responsibility for overseeing production of the video resources used in the Curriculum Support Units. These public sector partners will retain ownership rights to all courseware developed for the project.

Screen Media Partners, a California-based consulting firm, will be responsible for obtaining private-sector underwriting revenue from a wide variety of sources to support the venture. In addition, they will be responsible for the project's technology planning and delivery services, as well as administrative activities for the partnership.

How Will It Work?

Interested schools will subscribe to The Curriculum Network and receive a library of Curriculum Support Units - seven to ten minute mini-programs combining audio and full motion video, which establish the links between identified curriculum areas and real-world reference points. The curriculum content can be customized for individual regions. Teachers will decide which Curriculum Support Units they wish to use and when. In-depth training will be included to help teachers best utilize this important resource.

An interconnected workstation will provide teachers and students the opportunity to access information and training from a variety of sources, such as the developing "information superhighway" and cable broadcasts, along with various other media. Materials from these sources may be collected for later use or "piped" directly into classrooms.

The subscription price will include the lease of all required technology. Schools may, after technology planning support from TCN, also choose to include other curricular or administrative technologies into their subscription. Because TCN has no proprietary interest in any specific hardware, the most appropriate technologies can be provided at the most affordable cost, while meeting the individual educational needs of each participating school.

How You Can Help

A total of $5 million is currently being sought to pilot test this innovative project in a 15-month phase of development and implementation. Underwriting support opportunities are available to private sector corporations and foundations, as well as public sector agencies.

This initial funding will cover the costs of curriculum design which will be tied to the National Education Goals and Goals 2000. Equipment designs and testing will be undertaken during the pilot phase as well. Approximately fifteen schools, representing both geographically and socio-economically diverse populations, will then host in-class testing of the curriculum and equipment. The pilot phase will conclude with a full evaluation, leading to a general roll out of the Network.

For more information:

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Appendix J

FIVE PART AGENDA
FOR AN
EDUCATION TECHNOLOGY ENTERPRISE

1. Aggregate the education technology market so industry will invest the same kind of creative talent and money in schools that it now invests in the entertainment market.

2. Train teachers to integrate technology into the curriculum.

3. Develop the processes necessary to select, buy, install, and maintain technology products in schools.

4. Stimulate the development of high-quality education materials to be used with the computers.

5. Establish technical standards to guide the development and selection of those educational products and materials.

Source:Horowitz, Barry M. (1993). A Technology agenda: Item 1: Aggregate the market. *The American School Board Journal*, 36.

Appendix K

COMPARISON OF TECHNOLOGY PLANS

The development of technology plans is a critical element of integrating educational technology into all facets of teaching and learning. Technology has come to be viewed as a key to the economic prosperity of our nation and should be accessible to students as a means of preparing for the challenges of the 21st Century, as well as utilized in the continuing education and training of the American workforce. With recently introduced initiatives by Congress and the Administration, the need for federal leadership in this effort has been recognized and the government's role is being defined.

Many states and national organizations have already begun to develop educational technology plans and have produced recommendations to ensure that the formation and implementation of quality technology programs and services are made available not only to educational institutions, but to society at large.

For the creation of a national plan for educational technology, it is important to review the recommendations of those plans that have already been devised and are currently in the implementation stages.

A matrix depicting various national technology plans has been created as a visual reference outlining similarities in each plan's recommendations and to highlight issues that should be strongly considered in a national plan.

The matrix key indicates whether each plan has given primary emphasis or secondary emphasis to a particular issue. Primary emphasis (solid circle) means considerable attention and direction were given to the particular recommendation in the plans. A mark of secondary emphasis (open circle) indicates the recommendation or issue was mentioned or implied in a plan, but not elaborated on.

Although many plans consider a wide array of important issues such as program adoptability/adaptability and addressing special needs, the comparison chart documents those recommendations that were found consistently throughout all of the plans.

Planning: The reviewed proposals include various forms of planning at all levels of government (national, state, and local) as a consensus builder on regional needs and solutions.

Access: Student, staff, and community access to technologies is referenced in every proposal and viewed as a means of empowering technology users by providing resources and services.

Staff Development: The integration of technology into curriculum and the ability to effectively utilize technology resources emerges as a fundamental issue for pre-service and in-service training.

Resource Availability: Interested parties are concerned with the availability of technical and informational resources for students, teachers, and school staff members.

Technical Assistance: To ensure effective application of technology in the learning environment, assistance from equipment purchasing and maintenance to technical operations and trouble-shooting are advised.

Telecommunications: Information, services, and resources received via telecommunication networking and distance learning provides equitable access to quality education programs.

Standards: Current and emerging technologies and innovative programs are often referenced in support of national and state standards of quality and achievement.

Assessment: Program evaluation and outcome-based student performance serve as measures of quality technological equipment and programs.

Business Partnerships: Business and civic partnerships provide support in learning environments for planning and funding resources.

Governance Structures: A coordinated system of governance structures (technology councils and offices of technology) would provide support and direction for implementing technology programs in schools.

Research and Development: Technology is advancing at such a rate that ongoing research and development into its production and application in schools is highly recommended.

Agency Coordination: The coordination of programs and services between various agencies is necessary to prevent duplication of programs and strengthen and streamline efforts.

Administration: Effective school/district management software and student information transfer via networking to reduce the burden of administrative record keeping, data collection, report generation, and resource management.

Funding: Adequate financial support from public and private sources is essential to the success of technology products and educational applications.

Workforce Preparation: Technology is a major factor in determining the economic competitiveness of the workforce 2000. Opportunity and access to technology will prepare students for the job market of tomorrow and continuing education and retraining of today's workforce population will maintain the nation's competitive edge.

Prepared by John Cradler and Elizabeth Bridgforth, Far West Laboratory

Comparison of State Technology Plans & Policy Documents

	Alabama	Arizona	California	Florida	Georgia	Hawaii	Kentucky	Michigan	Montana	New Jersey	New Mexico
PLANNING											
National											
State	●	○	●	○	●		●	●	●	○	●
Local	●	○	●		○		●	●	●	○	●
ACCESS											
Students		●	●	●	●	●	●	●	○	●	●
Teachers	●	●	●	●	●		●	●		●	
Community	○		●	●	●		○			●	
STAFF DEVELOPMENT											
Pre-service	○		●	○			○	●		○	●
In-service	●	●	●	●	●	●	○	●	●	●	●
Curriculum Integration	●	●	○	○	●		●	●		●	○
RESOURCE AVALIBILITY											
Students	○	●	●	●		●	●		●	●	○
Teachers	●	●	●	●	●		●	●		●	○
Staff		○	●	○			○	●		●	
TECHNICAL ASSISTANCE	○		○	●	○		●		○	○	○
TELECOMMUNICATIONS											
Networking Infrastructure	●	●	●	●	○	●	●	●	●	●	○
Distance Learning	●	○		●	○	●	○	○	●		●
STANDARDS											
Technical (equipment)	●		○		○	○	●	○		○	○
Programs/Application	○		○		○	○	●	○		○	○
ASSESSMENT											
Students (outcome-based)	○		●		○		●				
Program Evaluation	○		●		○	○	○	●		○	●
BUSINESS PARTNERSHIPS											
Planning			●		○		○	○	○		○
Funding	●	●	●		○		○	●		○	○
GOVERNANCE STRUCTURES											
Technology Council/Agency			●	●			○		○	●	●
Office of Technology			●			●					●
Technology Committee		○	●				○			●	
RESEARCH & DEVELOPMENT											
New Products					○						
Programs	○		○		○						○
AGENCY COORDINATION			○	○				●	○	○	●
ADMINISTRATION											
Student Information Transfer	○	○	●	○			●	○			○
School/District Management	●	●	●	●	●		●	●			○
FUNDING											
Public	●	●	●	●	●	●	○	●	●	●	●
Private	●	●	●		○			●	●	●	
WORKFORCE PREPARATION											
School to Work	●		○		○		●	●		○	●
Continuing/Retraining		●	○	○				●	●		

● = Primary Emphasis
○ = Secondary Emphasis

	New York	North Carolina	Oklahoma	South Carolina	Tennessee	Texas	Utah	Virginia
PLANNING								
National								
State	●		●	○	●	○		●
Local	●		●	●		●	●	
ACCESS								
Students	●		●	●	●	●	●	○
Teachers	●		●	●	●	●	○	○
Community		●	●	●	○	●	○	○
STAFF DEVELOPMENT								
Pre-service	○			●		○	●	
In-service	○			●	○	●	●	●
Curriculum Integration	○			●		●		○
RESOURCE AVALIBILITY								
Students	○	●		●	●	○	●	●
Teachers	○	●		●	●	○	●	●
Staff				●		○		○
TECHNICAL ASSISTANCE	○			●		○	○	
TELECOMMUNICATIONS								
Networking Infrastructure	●	●		●	●	●	●	○
Distance Learning	●		●	○		●		●
STANDARDS								
Technical (equipment)			○	●	●	●		●
Programs/Application			○	●		●	●	●
ASSESSMENT								
Students (outcome-based)		○				●		●
Program Evaluation	○	○		●		○		●
BUSINESS PARTNERSHIPS								
Planning	○		●			○		●
Funding			●	●				
GOVERNANCE STRUCTURES								
Technology Council/Agency					○			●
Office of Technology								
Technology Committee	○		●					
RESEARCH & DEVELOPMENT								
New Products						●		
Programs			○			●	○	○
AGENCY COORDINATION	○			○				○
ADMINISTRATION								
Student Information Transfer	●	○		○	●		○	●
School/District Management	●	○		●	○	●	○	●
FUNDING								
Public	○		●	●		●	○	●
Private			○				○	○
WORKFORCE PREPARATION								
School to Work		●		●	●	○	○	●
Continuing/Retraining						○		○

● = Primary Emphasis
○ = Secondary Emphasis

Far West
LABORATORY

Comparison of Technology Plans and Policy Documents

	[illegible]	CDE	CCSSO	[illegible]	ISTE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	OTA
[illegible]											
National	●									●	○
State	●		●								○
Local	●		○	●							○
[illegible]											
Students	●	●	○	○		○	●	●	○	○	
Teachers	●	●	●	●	●	○	●	●	○	●	
Community				○	●		○	●	○	○	
[illegible]											
Pre-service		●	○	●	●		●			●	●
In-service	●	●	○	●	●		●			●	●
Curriculum Integration	●	●	●	●	○		○	○	○		
[illegible]											
Students	○	●	●		●		●	●	●		
Teachers	●	●	●		●		●	●	●		
Staff	○	●	○				●				
[illegible]	●	○	●		●		○			●	●
[illegible]											
Networking Infrastructure	●	●	●	●	●	○	●	●	●	●	●
Distance Learning	●		●	○	●						●
[illegible]											
Technical (equipment)	○	○	○	●				●			
Programs/Application	●	○		○			●		●		
ASSESSMENT											
Students (outcome-based)	●	●	●		●	●					○
Program Evaluation	●	●	○		○	●					
BUSINESS PARTNERSHIPS											
Planning	●	●		○			○	○	●		
Funding	●	●			○			○			
GOVERNANCE STRUCTURES											
Technology Council/Agency	●	●	○								
Office of Technology	●	●	○								
Technology Committee		●	○								
RESEARCH & DEVELOPMENT											
New Products	●	●	●	○				●	●		
Programs	○	●	●					●			○
AGENCY COORDINATION	●	○	○					●	●		○
ADMINISTRATION											
Student Information Transfer	●	●	○	○	●	●					
School/District Management	●	●	○								
FUNDING											
Public	●	●	●				●	●	●	●	○
Private	●		○					●	●	○	
WORKFORCE PREPARATION											
School to Work	●	○			○	○	●	●	●		
Continuing/Retraining	●	○						●	●		

● = Primary Emphasis
○ = Secondary Emphasis

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